UNBURNED HYDROCARBONS

UNIVERSITY OF MICHIGAN
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HEARING

BEFORE A

SUBCOMMITTEE OF THE COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE HOUSE OF REPRESENTATIVES

EIGHTY-FIFTH CONGRESS

SECOND SESSION

ON

H. R. 9368

A BILL TO PROHIBIT THE USE IN COMMERCE OF ANY MOTOR VEHICLE WHICH DISCHARGES UNBURNED HYDROCARBONS IN AN AMOUNT WHICH IS FOUND BY THE SURGEON GENERAL OF THE PUBLIC HEALTH SERVICE TO BE DANGEROUS TO HUMAN HEALTH

MARCH 17, 1958

Printed for the use of the Committee on Interstate and Foreign Commerce

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UNBURNED HYDROCARBONS

MONDAY, MARCH 17, 1958

HOUSE OF REPRESENTATIVES,
SPECIAL SUBCOMMITTEE ON TRAFFIC SAFETY,
COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE,
Washington, D. C.

The subcommittee met at 10 a. m., pursuant to notice, in room 1334, House Office Building, Washington, D. C., Representative Kenneth A. Roberts (chairman of the subcommittee) presiding.

Present: Representatives Kenneth A. Roberts, Samuel N. Friedel, J. Carlton Loser, Alvin R. Bush, and Paul F. Schenck.

Mr. ROBERTS. The subcommittee will please come to order. First of all, let me say that I am very happy that we have had such a fine response to the invitations which went out from this subcommittee.

We have gentlemen here from many parts of the country, and we appreciate the fact that some of you have come here from great distances, and at a great deal of sacrifice on your parts. We are going to have to try to move along as rapidly as possible, but I would appreciate it very much if, in making your presentations, you will bear in mind that we are operating on a limited schedule. It will be helpful if you will try to be as efficient as you can in making your presentations.

Today we are to consider H. R. 9368, a bill introduced by our distinguished colleague from Ohio, Representative Paul F. Schenck, which would prohibit the use in commerce of any motor vehicle which discharges unburned hydrocarbons in an amount found by the Surgeon General of the United States Public Health Service to be dangerous to public health.

(The bill referred to, and departmental reports thereon, follow:)

[H. R. 9368, 85th Cong., 1st sess.]

A BILL To prohibit the use in commerce of any motor vehicle which discharges unburned hydrocarbons in an amount which is found by the Surgeon General of the Public Health Service to be dangerous to human health

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That (a) the Surgeon General of the Public Health Service (hereinafter in this Act referred to as the "Surgeon General"), shall, after conducting such research as he may deem to be necessary but not later than six months after the date of enactment of this Act, prescribe and publish in the Federal Register, standards as to ahe amount of unburned hydrocarbons which is safe, from the standpoint of human health (with particular reference to the carcinogenic nature of unburned hydrocarbons), for a motor vehicle to discharge into the atmosphere.

(b) Standards prescribed pursuant to subsection (a) of this section may be revised from time to time by the Surgeon General. Such revised standards shall be published in the Federal Register.

SEC. 2. (a) No person shall use any motor vehicle in commerce which discharges unburned hydrocarbons in amounts in excess of the standards prescribed by the Surgeon General pursuant to the first section of this Act.

(b) Whoever violates this section shall be fined not more than $500, or imprisoned not more than 1 year, or both.

SEC. 3. As used in this Act—

(1) The term "commerce" means commerce among the several States, with foreign nations, in any Territory, or in the District of Columbia, or between any Territory and a foreign nation, or between the District of Columbia and any State;

(2) The term "Territory" includes the Territories and possessions of the United States and the Commonwealth of Puerto Rico; and

(3) The term "motor vehicle" means any vehicle propelled by mechanical power and used for transporting passengers or freight whether on a fixed track or on a highway.

SEC. 4. Section 2 (a) of this Act shall take effect 1 year after the date on which standards are first prescribed and published in the Federal Register pursuant to subsection (a) of the first section of this Act and thereafter any standards which are revised pursuant to subsection (b) of the first section of this Act shall take effect 1 year after the date on which they are published in the Federal Register.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,
Washington, D. C., February 20, 1958.

Hon. OREN HARRIS,
Chairman, Committee on Interstate and Foreign Commerce,
House of Representatives, Washington, D. C.

DEAR MR. CHAIRMAN: This letter is in response to your request of August 23, 1957, for a report on H. R. 9368, a bill to prohibit the use in commerce of any motor vehicle which discharges unburned hydrocarbons in an amount which is found by the Surgeon General of the Public Health Service to be dangerous to human health.

The bill would provide that the Surgeon General of the Public Health Service prescribe and publish in the Federal Register, not later than 6 months after the date of enactment of the act, standards as to the amount of unburned hydrocarbons which is safe, from the standpoint of human health (with particular reference to the carcinogenic nature of unburned hydrocarbons), for a motor vehicle to discharge into the atmosphere.

It would provide criminal penalties for any person using in commerce in the Territories or the District of Columbia, in interstate commerce, or in commerce with foreign nations, a motor vehicle which discharges unburned hydrocarbons in amounts in excess of such standards.

Research experts who are working on this problem in this Department advise that the scientific information required to justify and furnish the quantitative basis for the establishment of health protection standards for unburned hydrocarbons in motor vehicle exhausts is not now available and such knowledge could not be developed realistically within the period specified in the bill.

The Public Health Service has further informed me that, in this respect, although carcinogenicity for some animals has been demonstrated in certain high-boiling fractions of petroleum, only certain groups of airborne hydrocarbons have been demonstrated to have carcinogenic properties in one species of animal. The extrapolation of such data to human beings would be premature at this time. Further, existing scientific knowledge does not provide quantitative data as to the other specific hazards to human health which may derive from hydrocarbons present in motor vehicle exhausts.

Research on these subjects is being supported by this Department and other organizations. In addition, this Department, as well as commercial and other agencies, is supporting research aimed at the elimination, or major reduction, of unburned hydrocarbons in motor vehicle exhausts.

In summary, there is not now available the scientific knowledge needed to carry out the purposes of the act. We would therefore recommend that the bill not be enacted by the Congress.

The Bureau of the Budget advises that it perceives no objection to the submission of this report to your committee.

Sincerely yours,

M. B. FOLSOM, *Secretary.*

THE SECRETARY OF COMMERCE,
Washington, D. C., March 4, 1958.

Hon. OREN HARRIS,
Chairman, Committee on Interstate and Foreign Commerce,
House of Representatives, Washington, D. C.

DEAR MR. CHAIRMAN: This letter is in reply to your request of August 23, 1957, for the views of this Department with respect to H. R. 9368, a bill to prohibit the use in commerce of any motor vehicle which discharges unburned hydrocarbons in an amount which is found by the Surgeon General of the Public Health Service to be dangerous to human health.

The legislation would direct the Surgeon General of the Public Health Service, after conducting such research as he may deem necessary but not later than 6 months after enactment, to prescribe and publish standards as to the amount of unburned hydrocarbons which would be safe, from the standpoint of human health, for a motor vehicle to discharge into the atmosphere. The use in interstate commerce of vehicles violating such standards would be prohibited.

This Department recommends against enactment of this legislation.

It is our opinion that present knowledge is insufficient to allow the establishment of contamination levels and that, even if such knowledge were sufficient, there is no method as yet of limiting the contamination levels in vehicular exhaust. While work is in progress on all the technical aspects of this problem it is believed that the 6 months' effective date for the conduct of research on the establishment of safety standards is completely unrealistic.

Furthermore, even if the technical aspects of this problem were solved and standards of safety established, the enforcement of such standards would pose difficult and costly administrative problems for the Federal Government. Motor vehicle safety inspection and enforcement are matters usually under State and local jurisdictions. There are approximately 65 million motor vehicles registered in the United States (excluding track runing vehicles) now, and this figure is expected to increase to 81 million by 1965. While methods for determining the amount of unburned hydrocarbons released do exist, they are not easily or cheaply applied. Moreover, it probably would be necessary to inspect vehicles at fairly frequent intervals, because the possibility of reducing this contamination would depend largely on proper vehicle maintenance.

The automobile industry has spent several million dollars in its continuing efforts to find a solution to the problem of unburned hydrocarbons. These continuing efforts by the automobile industry will eventually solve this problem and represent, in our belief, a sounder approach to the problem.

For the above reasons, this Department recommends against enactment of this legislation.

The Bureau of the Budget has advised that it would interpose no objection to the submission of this report to your committee.

Sincerely yours,

SINCLAIR WEEKS,
Secretary of Commerce.

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D. C., February 14, 1958.

Hon. OREN HARRIS,
Chairman, Committee on Interstate and Foreign Commerce,
House of Representatives, New House Office Building,
Washington, D. C.

MY DEAR MR. CHAIRMAN: This is in reply to your committee's request for the views of the Bureau of the Budget dated August 23, 1957, on H. R. 9368, a bill to prohibit the use in commerce of any motor vehicle which discharges unburned hydrocarbons in an amount which is found by the Surgeon General of the Public Health Service to be dangerous to human health.

This proposed legislation would authorize the Surgeon General of the Public Health Service to establish standards governing the discharge of unburned hydrocarbons from motor vehicles. These standards would be based upon a determination of the effect of such unburned hydrocarbons on human health with particular reference to their cancer-producing characteristics. The bill would prohibit the use of vehicles discharging hydrocarbons in amounts in excess of the established standards and would provide a penalty for any violations.

In reporting on this measure the Department of Health, Education, and Wel-

fare points out that at the present time the amount of scientific information required to establish and support standards governing the safe level of unburned hydrocarbons in motor vehicle exhausts is not available and it is not likely that the required knowledge could be developed in the time prescribed in the bill. The Department of Commerce, in its views on the same bill, raises the additional problem of the difficulties of administering the bill. These problems of administration originate in the large number of motor vehicles that would have to be frequently inspected, the inadequacies in the available methods for testing the discharge of unburned hydrocarbons, and the fact that motor vehicle safety inspection and enforcement are matters traditionally under State and local jurisdiction.

We would concur in the conclusions reached by the Departments of Commerce and Health, Education, and Welfare and join them in recommending against enactment of this legislation.

Sincerely yours,

ROBERT E. MERRIAM,
Assistant Director.

Mr. ROBERTS. The subcommittee may recall that questions of the seriousness of this problem have some up indirectly from time to time in previous hearings. At least one of our witnesses here today has previously testified as to the importance of the problem. That is Dr. Zipf, who comes from Dayton, Ohio.

The subcommittee is grateful to those of you who have taken the time to appear before us and testify today, and we anticipate that your appearance will be of great value in the consideration of Representative Schenck's bill.

Our first witness, I believe, is to be Dr. Paul Kotin——

Has he arrived?

Our next witness, then, will be Mr. Harold W. Kennedy, county counsel of Los Angeles County, Calif.

Will you come forward at this time, Mr. Kennedy? We will be happy to hear from you.

STATEMENT OF HAROLD W. KENNEDY, COUNTY COUNSEL OF LOS ANGELES COUNTY, LOS ANGELES, CALIF.

Mr. KENNEDY. Congressman Roberts, and gentlemen of the committee. My name is Harold W. Kennedy. I am the county counsel of the county of Los Angeles, and the attorney for the Los Angeles County Air Pollution Control District. Pursuant to your request, Congressman Roberts, I will comply with your time-schedule situation; and, rather than read in full the 20-page statement which I prepared before leaving Los Angeles, I will file it with the clerk and ask that it be reported in the record as my first statement.

Then I would like to supplement the high points of the report, with your permission.

Mr. ROBERTS. Without objection, the statement will be incorporated in the record.

(The statement referred to follows:)

STATEMENT OF HAROLD W. KENNEDY, COUNTY COUNSEL OF THE COUNTY OF LOS ANGELES AND ATTORNEY FOR THE LOS ANGELES COUNTY AIR POLLUTION CONTROL DISTRICT, IN SUPPORT OF H. R. 9368, INTRODUCED BY CONGRESSMAN PAUL F. SCHENCK FROM THE THIRD DISTRICT OF OHIO

Presented to the Traffic Safety Subcommittee of the House of Representatives on March 17, 1958, Washington, D. C.

The taxpayers and citizens of the county of Los Angeles have already paid a big price for clean air. Furthermore, they are willing to continue to pay large

sums in tax money and through industrial investment in control devices in order to be relieved of the discomfort and danger to public health brought about by aerial sewage.

The county of Los Angeles has pioneered the Nation in effective air-pollution control. It drafted and sponsored the 1947 Air Pollution Control Act (secs. 24198–24323, California Health and Safety Code), and activated the first Air Pollution Control Act in California, the largest of its kind in the Nation. From its very inception, the Board of Supervisors of Los Angeles County has vigorously insisted upon a strict air-pollution control program, and as the technology has developed in scientific research involving air pollution, pursuant to the authority granted by the California Air Pollution Control Act the board of supervisors has adopted strict rules and regulations. Outstanding cooperation has been received both from industry and from the public.

During the first 9 years of the Los Angeles County Air Pollution Control District, $10,600,000 of Los Angeles County taxpayers' money has been paid out in support of air pollution control district expenditures. During this same 9-year period (1948 through 1957) under the rulemaking power of the district, industry was required to invest in many types of control devices and spent for such purposes, in the aggregate, $49,900,000. In addition to these two sums, research expenditures by other agencies in the Los Angeles County area amounted to $12,500,000. Therefore, the staggering sum of $73 million has been expended through public and private funds in Los Angeles County, which documents a large measure of self-help in battling California's second most important problem.

Proposals for the 1957–58 Los Angeles County Air Pollution Control District budget provided for a continuation of the accelerated inspection, enforcement, and engineering program pursued since 1955. More money than ever has been asked for research into the vexing problems of motor-vehicle exhaust and solvent emissions. Detailed performance tests, on the road and in the laboratory, are being performed by Mr. S. Smith Griswold, air pollution control officer, and his staff to determine the effectiveness of experimental control devices developed by outside agencies. Under the district's supervision, various catalysts are being tested under laboratory conditions to determine their potential effectiveness in removing significant hydrocarbons and smog-forming organic compounds from motor exhausts. Mr. Griswold has engaged in a detailed study of the specific properties of motor exhaust, of the variations which occur during different operating conditions, and of the quantities and effects of contaminants emitted under typical driving conditions. The purpose of these studies is to determine the efficiency required of automobile exhaust-control devices. Furthermore, the district has engaged in an intensive investigation of the effects of fuel composition on the emission of smog-forming materials from auto exhausts.

In a recent Los Angeles County APCD progress report, Air Pollution Control Officer S. Smith Griswold reported to the board of supervisors and to the public as follows:

"THE BILL: $300 MILLION

"How long it will take, no one can say. This much is sure: the job will not be inexpensive.

"The cost of clean air will be heavy. Over the next 5 years alone, some estimates indicate that approximately $300 million will be required to combat the Los Angeles problem—$30 million for industrial control devices, $15 million for research by agencies other than the APCD, $150 million or more for equipping local vehicles with exhaust-control devices, $45 million or more for refuse collection and disposal services, and $15 million to finance the several activities of the air pollution control district."

These figures are cited to outline the magnitude of the problem and the vigorous steps already taken in Los Angeles County to combat the smog evil.

Indicative of the strong support and cooperation from the 5,500,000 people in the county of Los Angeles was their ready acceptance of the prohibition against the antiquated practice of rubbish burning, effective throughout the county, including all of the cities, on October 1, 1957.

The official position of the county of Los Angeles is set forth in the following resolution adopted by the board of supervisors on March 11, 1958, reading as follows:

"RESOLUTION PRESENTED BY SUPERVISOR WARREN M. DORN, LOS ANGELES COUNTY BOARD OF SUPERVISORS, TUESDAY, MARCH 11, 1958

"Resolution supporting and requesting support for House of Representatives bill 9368, to prohibit the use in commerce of any motor vehicle which discharges unburned hydrocarbons in an amount which is found by the Surgeon General of the Public Health Service to be dangerous to human health

"Whereas motor-vehicle exhausts have been established as the principal cause of eye irritation, reduced visibility, and damage to growing vegetation in the Los Angeles Basin at the present time; and

"Whereas all other significant sources of air pollution in this area already have been controlled or are now being controlled through rules and regulations enacted by the Board of Supervisors of the County of Los Angeles, having jurisdiction over the county and air pollution control district; and

"Whereas the control of motor-vehicle exhausts now constitutes the principal problem confronting the Los Angeles County air pollution control program, and motor-vehicle exhausts are considered to be a problem in other metropolitan and urban areas of California and the Nation, combustion products contained in motor-vehicle exhausts being suspected as a serious hazard to the public health; and

"Whereas the recently published findings of the assembly interim committee on public health of the California Legislature point to hydrocarbon emissions from motor vehicles as a very real hazard to the health and welfare of the residents of urban areas; and

"Whereas H. R. 9368 introduced by Congressman Paul L. Schenck, of the Third District of Ohio, now pending before the 1st session of the 85th Congress, would prohibit the use in commerce of any motor vehicle which discharges unburned hydrocarbons in an amount dangerous to human health, and calls upon the Surgeon General of the United States to be responsible for determining and publishing safe standards of hydrocarbon emission from motor vehicles; and

"Whereas such standards would be established and enforced following the completion of such research by the Surgeon General as is necessary to the promulgation of such standards; and

"Whereas the administration of such research and the promulgation of such standards by Federal authorities is consistent with the policies of the Los Angeles County Air Pollution Control Board and the purposes of the Los Angeles air pollution control program, and the Surgeon General already has been declared responsible for the administration of a Federal air pollution research program, under the terms of Public Law 159; and

"Whereas the Los Angeles County Air Pollution Control Board has expressed approval of the policies incorporated in Public Law 159 and has expressed itself in favor of more intensive research in this area; and

"Whereas the board of supervisors acting as the Air Pollution Control Board of Los Angeles County, on February 20, 1958, instructed county counsel and the air pollution control officer to advise as to the earliest practicable date for holding a hearing to consider a proposed rule to prohibit the expulsion of hydrocarbons or other pollutants through the exhaust of internal combustion engines; and

"Whereas the Federal Government is the logical agency to prescribe and publish standards as to the amount of unburned hydrocarbon from motor-vehicle exhausts which is safe from the standpoint of human health and welfare; and

"Whereas the Secretary of Health, Education, and Welfare has recognized the importance of motor-vehicle exhausts and other pollution sources to the occurrence of air-pollution problems throughout the Nation by his forthcoming sponsorship of a national symposium on this subject; and

"Whereas the Surgeon General and the National Advisory Committee on Community Air Pollution to the Surgeon General have recognized as an immediate and increasing problem the control of air pollution emanating from the automobile exhaust: Now, therefore, be it

"*Resolved*, That the Air Pollution Control Board of Los Angeles County advise the California delegation in Congress to lend its support to the principles contained in H. R. 9368 regarding the establishment by Federal authorities of permissible hydrocarbon emission standards for motor vehicles; and be it further

"*Resolved*, That the State of California, through its executive and legislative branches of government, be urged also to take whatever action is deemed necessary to support this legislation, by reasons of air pollution problems existing in the San Francisco Bay area, the San Joaquin Valley, and San Diego; and be it further

"*Resolved*, That Supervisor Warren M. Dorn, chairman of the air pollution control committee of the Board of Supervisors of Los Angeles County, be authorized to attend congressional committee hearings considering action of H. R. 9368, or any similar legislation, and that county counsel Harold W. Kennedy and air pollution control officer, S. Smith Griswold, of Los Angeles County, be instructed to appear before such committees originally considering action on March 17, 1958, and to provide such committees any technical information required regarding the contribution of motor-vehicle exhausts to the air-pollution problem in this area."

The county of Los Angeles recognizes that the provisions of Congressman Schenck's H. R. 9368 call for stern measures on the part of the Surgeon General of the Public Health Service and place upon him the responsibility of setting forth standards as to the amount of unburned hydrocarbons which is safe from the standpoint of human health (with particular reference to the carcinogenic nature of unburned hydrocarbons) that a motor vehicle can discharge into the atmosphere. The representatives of Los Angeles County fully recognize that the prohibitions contained in section 2, to the effect that "No person shall use any motor vehicle in commerce which discharges unburned hydrocarbons in amounts in excess of the standards prescribed by the Surgeon General * * *," have the effect of requiring the automotive industry to do more than it has done up to the present time as its contribution toward the development of either improved automotive engineering or effective control devices that will further serve to reduce the volume of pollutants going into the air from automobiles in every city in the United States. However, despite the sternness of these requirements, it is our belief that action by legislative bodies such as the Congress of the United States is necessary. It is our experience over the 9 years that improvements in air pollution control have been brought about largely through the determination of standards and the fixing of deadlines within which those standards must be met.

There is nothing that I could say which would put in sharp focus the need for affirmative action on the part of the Congress along the lines of Congressman Schenck's H. R. 9368, more than the official report of the Department of Public Health of the State of California (see Annual Report Issue—The Clean Air Quarterly, published by State of California, Department of Public Health, vol. 2, No. 1, March, 1958). This report has been prepared under the direction of Malcolm H. Merrill, M. D., director of public health. Pertinent parts of that report are as follows:

"Through its extensive control program, the Los Angeles Air Pollution Control District has reduced the quantity of pollutants being discharged to the atmosphere. Mostly because of a lack of known control methods, it has not been able to control nitrogen dioxide emissions from combustion sources and hydrocarbon from motor vehicle exhausts.

* * * * * * *

"The Los Angeles County Air Pollution Control District has had an active enforcement program and has reduced emissions to the atmosphere from many sources. * * * It should be noted that the marked reduction in pollutants in recent years has prevented more serious air pollution in Los Angeles than it has had, and probably accounts for some of the improvement observed in 1957.

* * * * * * *

"Prospects for a further sharp reduction in air pollutants in Los Angeles are poor until a control device for motor vehicle exhaust is available. Because adoption of regulations and installation of control devices take time, it will be a few years before pollutants from sources now under control in Los Angeles will be appreciably reduced in other parts of the State also.

* * * * * * *

"Research indicates that eye irritation and crop damage are related to automobile exhaust. *Automobile exhaust is also known to be associated with the liberation into the atmosphere of substances which in the laboratory are known to cause cancer. It would be a tragic mistake to be content with the elimination of eye irritation only to find, in a decade, that our populations had been exposed for years to cancer-producing substances in quantities capable of producing disease. By that time preventive measures would be too late.*" [Emphasis added.]

Specific attention is called to the source of these prognostications. They represent the studied and carefully weighed opinion of the Department of

Public Health of the State of California, based upon years of research and recognizing their heavy responsibility in not unduly alarming the public in their assertion that "Automobile exhaust is also known to be associated with the liberation into the atmosphere of substances which in the laboratory are known to cause cancer."

By way of additional evidence to support the public policy of adequate controls, attention is called to the report of the assembly interim committee on public health, subcommittee on the health effects of smog, filed with the California Legislature on March 10, 1958. This report is entitled "Air Pollution and the Public Health." This important report points up with emphasis the serious impact of smog upon urbanized communities, and it must be remembered that the situation that has already developed in the metropolitan areas of California are being duplicated in many population centers throughout the United States. In no sense is the smog problem indigenous to California alone.

Among the important findings, conclusions, and recommendations of this special legislative committee, which has been studying the problem under the leadership of Assemblyman Thomas M. Rees, chairman, and Assemblyman Charles Wilson and Seth Johnson, are the following:

HEALTH FACTORS OF SMOG

* * * * * * *

"There is an immediate disaster potential in California smog which could, if given the right conditions, be as serious as the London, England, and Donora, Pa., deaths.

"There is a long-range health problem with California smog. The effect of ozone on the lungs and bentzpyrene as a carcinogenic factor represent what could easily be a long-term health problem.

"There is no coordinated research program in the field of air pollution between Federal, State, and local government and private research groups.

* * * * * * *

"The medical research program is very weak, strikingly so when one considers what the medical effects of air pollution could be."

If these findings, conclusions, and recommendations constitute the calculated and sober judgment of men of responsibility at the State level, they place in sharp focus the need for agressive action at the level of the Federal Government.

It is for these reasons that Supervisor Warren M. Dorn, in his chairmanship of the Los Angeles County Air Pollution Control Committee, has called the attention of the board of superivsors and the people of the county of Los Angeles and the State of California to the importance that must be given to "ascertaining standards and fixing deadlines" if the air pollution problem as effected by motor vehicles is to be adequately and satisfactorily faced up to in the public interest.

With respect to the legal aspects of ascertaining standards and adopting reasonable rules and regulations and fixing deadlines for their completion, there is no question whatsoever as long as they are both understandable and reasonable. In its pioneering effort, Los Angeles County, through its county counsel's office, researched the fundamental, legal, and constitutional issues involved in the strict enforcement of an air pollution control program.

The leading case in the United States in the field of air pollution control law is still *Northwestern Laundry* v. *Des Moines* (239 U. S. 486, 36 S. Ct. 206, 60 L. Ed. 396), passed upon by the Supreme Court of the United States as early as 1916. That case, as do a number of cases in the State courts, holds that ordinances prohibiting the emission of dense smoke in cities or populous neighborhoods, and also ordinances that prescribe a definite scientific standard for the density of smoke, such as the Ringlemann Scale, are valid so far as constitutional limitations are concerned. In the Des Moines case, the smoke inspector and members of the smoke abatement commission of that city sought to enjoin the enforcement of a Des Moines ordinance providing that the emission of dense smoke in portions of the city was a public nuisance. It was claimed that the ordinance was void under the due process and equal protection clause of the 14th amendment in that, among other things, the ordinance prescribed arbitrary tests of degrees of density. The practical effect of the standard of efficiency required the remodeling of practically all furnaces in the city of Des Moines. It forbade remodeling or new construction without a license and gave discretion to the smoke inspector

and abatement commissioners to prescribe requirements. The court held the ordinance valid and dismissed the bill upon its merits, stating:

"So far as the Federal Constitution is concerned we have no doubt the State may by itself, or through authorized municipalities, declare the emission of dense smoke in cities or populous neighborhoods a nuisance and subject to restraint as such; *and that the harshness of such legislation, or its effect upon business interests, short of a merely arbitrary enactment, are not valid constitutional objections. Nor is there any valid Federal constitutional objection in the fact that the regulation may require the discontinuance of the use of property, or subject the occupation to large expense in complying with the terms of the law or ordinance.*" [Emphasis added.]

In a still earlier case, that of *State* v. *Tower* (1904) (185 Mo. 79, 68 L. R. A. 402, 84 S. W. 10), in upholding the validity of an air pollution control ordinance, it was held:

"It was entirely competent for the legislature to take cognizance of the fact, known to all men, that the emission and discharge of dense smoke into the atmosphere of a large and populous city is of itself a nuisance * * * and one calculated to interfere with the health and comfort of the inhabitants thereof, and to declare it a nuisance per se * * * We have no hesitancy in holding that it was entirely competent for the legislature to declare the emission of dense smoke in the open air in a city of 100,000 inhabitants a nuisance per see."

More than 4 years ago, at the time the county of Los Angeles was having an exchange of correspondence with executives of the automobile industry in the county's effort of securing from them the cooperation that would be required to whip the auto exhaust problem, Supervisor Kenneth Hahn of the Los Angeles County Board of Spuervisors requested an opinion from the Los Angeles County Counsel's Office as to whether or not it would be legal for the air pollution control district, under its rulemaking power, to require an auto exhaust control device on every new motor vehicle sold for use in Los Angeles County. On October 27, 1953, we rendered the following opinion:

"On September 14, 1953, you requested our opinion as to whether the board of supervisors, sitting as the air pollution control board, after notice and hearing expert testimony that automobile exhaust gases are a material contribution to the smog problem, could require every new automobile sold in this county for use here, including those sold in cities, to be equipped with a device which would eliminate or reduce exhaust gases, or set a time limit after which any new automobile, bus or truck would be required to be equipped with such a device approved by the air pollution control district.

"Our answer is that the rulemaking power of the board of supervisors, sitting as the air pollution control board, is broad enough to cover almost any conceivable situation in connection with the control of air pollution in this county. Such powers, however, may not be exercised arbitrarily, capriciously, or unreasonably. Board action must be based on proven facts or sound scientific opinion. As the engineers and chemists discover new sources of, or new remedies for air pollution, the board's power extends to these new sources and remedies. Answering your question more specifically, the board will have the power to require motor vehicles to be equipped with a device to eliminate the emission of air contaminants as soon as such a device is perfected, shown to be effective, available on the market, and the requirement of its use is found to be reasonable.

"Our reasons are as follows:

"The rulemaking power of the board of supervisors, sitting as the air pollution control board, extends to everything which causes air pollution or emits contaminants.

"Section 24260, Health and Safety Code, authorizes the board of supervisors, sitting as the air pollution control board, to make rules and regulations effective throughout the county. It reads as follows:

" 'The air pollution control board of an air pollution control district may make and enforce all needful orders, rules, and regulations necessary or proper to accomplish the purposes of this chapter for the administration of such district, and may perform all other acts necessary or proper to accomplish the purposes of this chapter.'

"The purposes of 'this chapter' are stated in section 24198, which reads as follows:

" 'The legislature finds and declares that the people of the State of California have a primary interest in atmospheric purity and freedom of the air from

any air contaminants and that there is pollution of the atmosphere in many portions of the State which is detrimental to the public peace, health, safety, and welfare of the people of the State.'

"Section 24262 states in further details the standards which the board must follow in enacting rules and regulations. This section reads as follows:

" 'Whenever the air pollution control board finds that the air in the air pollution control district is so polluted as to cause any discomfort or property damage at intervals to a substantial number of inhabitants of the district, the air pollution control board may make and enforce such orders, rules, and regulations as will reduce the amount of air contaminants released within the district.'

"We are informed that motor-vehicle exhausts do emit substantial smoke and fumes. If so, they are therefore within the jurisdiction of the air pollution control board to regulate if it finds that the air in the district is so polluted as to cause discomfort or property damage at intervals to a substantial number of inhabitants and that the proposed regulation will reduce the amount of air contamination released within the district.

"Were the situation sufficiently serious and the fumes from motor vehicles sufficiently dangerous to make such action reasonable, the board would probably be sustained in prohibiting the use of motor vehicles entirely, at least in the downtown area, until such time as a control device is available. Obviously, the situation is not critical enough now to justify such drastic action. We mention this only to show the extent of the board's powers when the facts make such action reasonable.

"In *Ballentine* v. *Nester* (350 Mo. 58; 164 S. W. 2d 378, at 383), the city of St. Louis, authorized to abate smoke, adopted an ordinance prohibiting the burning of soft coal except when used with a mechanical stoker. In that case, the court said (164 S. W. 2d at 382–383):

"* * * There can be no doubt that under the above sections that the legislative department of the city of St. Louis has the power to abate the smoke nuisance in the city by any reasonable method. To accomplish that object, it enacted section 5340, supra. This section sought to obtain that object by regulating the kind of coal that can be burned in that city. * * * "That the smoke nuisance is directly contributed to and almost wholly caused by burning of soft or bituminous coal is a matter of general knowledge, * * *." * * * "The methods, regulations, and restrictions to be imposed to attain, so far as may be, results consistent with the public welfare, are purely of legislative cognizance. The courts have no power to determine the merits of conflicting theories, nor to declare that a particular method of advancing and protecting the public is superior or likely to insure greater safety or better protection than others. The legislative determination of the methods, restrictions, and regulations is final, except when so arbitrary as to be violative of the constitutional rights of the citizens."

" '* * * It is "sufficient to satisfy the demand of the Constitution if a classification is practical and not palpably arbitrary."

" 'Coal burned mechanically tends to create less smoke than the same coal burned by hand. Coal burned mechanically is distributed evenly in the firebox of the furnance and would tend to produce less smoke than coal that is distributed unevenly by hand, and this is true even if firing by hand is carefully performed. Since there is a reasonable classification between how the same coal is burned, and it applied equally and uniformly to all coal users in the city of St. Louis, we cannot say that it is an arbitrary classification.'

"In *Northwestern Laundry Co.* v. *Des Moines* (239 U. S. 486; 60 L. Ed. 396, 401; 36 S. Ct. 206, 208), the court said:

" 'So far as the Federal Constitution is concerned, we have no doubt the State may by itself, or through authorized municipalities, declare the emission of dense smoke in cities or populous neighborhoods a nuisance and subject to restraint as such; and that the harshness of such legislation, or its effect upon business interests, short of a merely arbitrary enactment, are not valid constitutional objections. Nor is there any valied Federal constitutional objection in the fact that the regulation may require the discontinuance of the use of property, or subject the occupant to large expense in complying with the terms of the law or ordinance. Recent cases in this court are *Reinman* v. *Little Rock* (237 U. S. 171, 59 L. Ed. 900, 35 Sup. Ct. Rep. 511); *Chicago & A. R. Co.* v. *Tranberger* (238 U. S. 67, 59 L. Ed. 1204, 35 Sup. Ct. Rep. 678); *Hadacheck* v. *Sebastian* (decided December 20th, 1915 (239 U. S. 394, ante, 348, 36 Sup. Ct. Rep. 143)).

" 'That such emission of smoke is within the regulatory power of the State has been often affirmed by State courts. *Harmon* v. *Chicago* (110 Ill. 400, 51

Am. Rep. 689); *Bowers* v. *Indianapolis* (169 Ind. 105, 81 N. E. 1097, 13 Ann. Cas. 1198); *People* v. *Lewis* (86 Mich. 273, 49 N. W. 140); *St. Paul* v. *Haugbro* (93 Minn. 59, 66 L. R. A. 441, 106 Am. St. Rep. 427, 100 N. W. 470, 2 Ann. Cas. 580); *State* v. *Tower* (185 Mo. 79, 68 L. R. A. 402, 84 S. W. 10); *Rochester* v. *Macauley-Fien Mill Co.* (199 N. Y. 207, 32 L. R. A. (N. S.) 554, 92 N. E. 641). And such appears to be the law in Iowa. *McGill* v. *Pintsch Compressing Co.* (140 Iowa, 429, 20 L. R. A. (N. S.) 466, 118 N. W. 786).'

"See also: *Judson* v. *L. A. Suburban Gas. Co.* (157 Cal. 168), where an injunction was granted at the request of a neighbor closing a gas plant where it was shown that, although it had the most modern equipment, it could not operate without emitting objectionable smoke and fumes. *Hulbert* v. *California Portland Cement Co.* (161 Cal. 239), where an $800,000 cement plant was closed under similar circumstances, notwithstanding the fact that the defendant was willing to buy up all of the property affected by its cement dust. *People* v. *Selby Smelting and Lead Co.* (163 Cal. 84), where the court in Solano County enjoined the operation of a smelter in Contra Costa County during the 8 months of each year when the winds blew toward Solano County.

"Rules of the air pollution control district are effective throughout the district. The district's boundaries are coextensive with those of the county (sec. 24201, Health and Safety Code). Thus, the rules of the district are enforceable within cities as well as in the unincorporated areas of the county. (See secs. 24247–24250, Health and Safety Code.)

"Section 24246, Health and Safety Code, authorizes the air pollution control officer to '* * * stop, detain, and inspect any vehicle designed for and used on a public highway but which does not run on rails.' Failure to stop for such inspection is a misdemeanor (sec. 24246, Health and Safety Code). Clearly, the Air Pollution Control Act applies to motor vehicles the same as to other sources of air contamination.

"The question might be raised as to whether the Vehicle Code has occupied the field so as to prevent the air pollution control board from adopting further regulations as to what equipment a motor vehicle must bear. Because of the different purposes involved, and because of the more recent and more specific authorization of the Air Pollution Control Act, we think that doctrine does not apply and the air pollution control board may require the use of such a device, if that is reasonable and practicable. Furthermore, division 9 of the Vehicle Code is entitled 'Traffic Laws.' It refers '* * * exclusively to the operation of vehicles upon the highways * * *' (sec. 457, Vehicle Code). It includes such matters as stop signs, reporting accidents, drunk driving, theft of a vehicle, speed limits, passing, turning, right-of-way, pedestrians, safety zones, parking, etc.

"Section 458 (a part of division 3), Vehicle Code, reads as follows:

" 'The provisions of this division are applicable and uniform throughout the State and in all counties and municipalities therein and no local authority shall enact or enforce any ordinance on the matters covered by this division unless expressly authorized herein.'

"Division 10 of the Vehicle Code deals with equipment, such as lights (sec. 61, et seq.), brakes (sec. 670), horns (sec. 671), mufflers (sec. 673), mirrors (sec. 674), windshields (sec. 675), safety glass (sec. 675.5), windshield stickers (sec. 676), and radiator ornaments (sec. 683). None of these provisions deal with smog-control devices.

"There is no provision in division 10 similar to the prohibition of local regulation in division 9.

" '* * * Where a statute, with reference to one subject contains a given provision, the omission of such provision from a similar statute concerning a related subject is significant to show that a different intention existed.' (*People* v. *Buster*, 11 Cal. 215 at 221; *Estate of Garthwaite*, 131 Cal. App. 321 at 326, 21 P. 2d 465; *People* v. *Valentine*, 28 Cal. 2d 121 at 142, 169 P. 2d 1; *Weil* v. *Superior Court*, 97 Cal, App. 2d 373 at 377, 217 P. 2d 975 at 978, *People* v. *Town of Corte Madera*, 97 Cal. App. 2d 726 at bottom of page 729, 216 P. 2d 810; *Richfield Oil Corporation* v. *Crawford*, 39 Cal. 2d 729 at 735, 239 P. 2d 600 at 604; 23 Cal. Jur. 778, Statutes, sec. 154.)

"We think it may be inferred that the legislature did not intend to occupy the field in connection with equipment required in division 10. Thus, the district may require additional equipment not in conflict with provisions of State law.

"The classification of motor vehicles in division 10 of the Vehicle Code for the purpose of requiring certain equipment, frequently distinguishes between new

and old vehicles. For instance, section 619, as to the location of headlamps, provides: '* * * except as to vehicles registered prior to January 1, 1930.' Section 621.5 requires vehicles to carry certain red reflectors after January 1, 1941, unless a different type was installed as original equipment prior to January 1, 1941.

"Section 625 formerly provided that certain clearance lamps be used on or after January 1, 1940, but that 'vehicles sold or operated prior to January 1, 1940, may be equipped with * * *' lights of another type. (See also secs. 645, 648, 670.4, 675.5 and 683, Vehicle Code.)

"Section 660 provides:

" 'No dealer shall sell a new or used motor vehicle without first testing and if necessary adjusting the lights and brakes on such vehicle to conform with the provision of this code unless such vehicle is sold for the purpose of being wrecked or dismantled.'

"Prior to 1951, this section provided: 'No dealer shall sell a used motor vehicle * * *.'

"Section 676 provides: '* * * Every new motor vehicle first registered after December 31, 1949, * * * shall be equipped with two such windshield wipers * **.'

"A regulation such as this is not invalid because it classifies the subject matter of the regulation. However, the classification must be reasonable in view of the purpose of the act. (*Rast* v. *Van Deman and Lewis Co.*, 240 U. S. 342, 357; 60 L. Ed. 679; *People* v. *Western Fruit Growers*, 22 Cal. 2d 494, 506–507.)

"Thus, treating new cars differently than other cars is a valid classification if reasonable under the circumstances. The ease of enforcement and the practical advantages of having the air pollution control device installed either at the factory or by a responsible new car dealer would seem to be sufficient to justify a distinction between new cars and old cars. This is particularly true if the device is difficult to install or requires replacement of major parts of the motor vehicle.

"Details of the proposed rule can best be worked out after some such device has been made available and its possibilities and limitations known. It may work on certain types of vehicles and not on others, or only with certain fuels. From its very nature it may have to be factory installed. Or it may be so simple that anyone can install it in a few minutes, in which case it might be unreasonable not to apply to it all motor vehicles. If it is practicable to add the device to vehicles not so equipped at the factory, the rule could set a time limit after which the use of the device would be required on all motor vehicles. The rule should exempt vehicles sold here for use elsewhere.

"It is not necessary that the legislation extend to all possible cases (*Miller* v. *Wilson*, 236 U. S. 373, 383; *Ballentine* v. *Nester*, 350 Mo. 58, 164 S. W. 2d 378, 383). In the Miller case, the Supreme Court said (236 U. S. at 393–4):

" '* * * The contention as to the various omissions which are noted in the objections here urged ignores the well-established principle that the legislature is not bound, in order to support the constitutional validity of its regulation, to extend it to all cases which it might possibly reach. Dealing with practical exigencies, the legislature may be guided by experience. (*Patsone* v. *Pennsylvania*, 232 U. S. 138, 144, 58 L. Ed. 539, 543, 34 Sup. Ct. Rep. 231.) It is free to recognize degrees of harm, and it may confine its restrictions to those classes of cases where the need is deemed to be clearest. As has been said, it may "proceed cautiously, step by step", and "if an evil is specially experienced in a particular branch of business" it is not necessary that the prohibition "should be couched in all-embracing terms." '

"However, we are informed by the air pollution control district engineers that there is no device on the market as yet which will reduce or eliminate the emission of fumes from motor vehicles. One device is being tested, another is still in the designing stage. It is not known whether either will work. Neither is it known how long it will be before some such device, after being proved practicable, will be available commercially.

"Until such a device is perfected and on the market, any rule requiring the use of the device is arbitrary, capricious, and void, unless the hazard to life and property is so great that a rule would be justified forbidding the sale or use of motor vehicles in this county. From the facts given to us, the board could conclude that there is no such emergency now in Los Angeles County. Once a satisfactory device is perfected, shown to be effective for the purpose

and practicable in operation, then the regulation proposed could be adopted, allowing sufficient time before it becomes effective to get the device on the market in reasonable quantities. As it is impossible to tell when such a device may be invented, or if invented, when perfected for motor vehicle use and shown to be practicable, no such regulation could be adopted now to be effective at a future date.

"We conclude that the rule you suggest, with certain modifications, can be adopted when the required device is available, but not until then."

Recent cases in the field of air pollution control law strongly buttress this legal conclusion, and we believe that given this problem, an appellate court would reach the conclusions above recited.

Our county counsel's office had occasion recently to again review the legality of requiring automotive exhaust control devices, and based upon the earlier ruling of *Northwestern Laundry* v. *Des Moines*, supra, and *Ballentine* v. *Nester* (350 Mo. 58, 164 S. W. 2d 378), where the courts have upheld the right of the legislative branch of Government to prescribe the methods, regulations, and restrictions to be imposed as a means of achieving the desired elimination of air pollutants as a proper exercise of the police power as long as the legislative determination is not arbitrary and unreasonable, it is our opinion that such principles would be applicable to sustaining a congressional act along the lines of H. R. 9368, proposed by Congressman Paul F. Schenck.[1]

During the almost 10-year history of the pioneering efforts of the county of Los Angeles through its respective agencies to, in good faith, measure up to the needs of the people in adequate and efficient air pollution control, it has been the policy of the Board of Supervisors of Los Angeles County to give full credit to the splendid cooperation which has been received generally from industry. More than 5 years ago, the automotive industry and its executives and engineers were called upon to extend themselves in a genuine and realistic way to engage in a program of research, experimentation and testing to reduce hydrocarbon pollutants from automobiles through improved engineering or a motor vehicle exhaust device, and for a time several million people in Los Angeles County believed that because of their vast financial resources, their great engineering skill, and because of the important part which motor vehicles played in the economy and life of Americans, that the automotive industry could enjoy the satisfaction of having furnished the leadership and the funds to develop the improvements needed. Some place in the record the assurance was given that when the 1958 models were in the showrooms they would contain an air pollution control device; 1958 models do not have such control devices, and up to the present time, definite and specific assurances have not been forthcoming from those great industrial concerns whose business it is to produce motor vehicles. It is the considered judgment of representatives from the county of Los Angeles that before real progress is made it will be necessary for boards of supervisors and county commissioners under their rulemaking power, State legislatures, and the Congress of the United States to "fix reasonable standards and outline reasonable deadlines" in order that the health of the American people may be fully protected.

It must be remembered that in the long history of government, its primary purpose is to protect the people; and that the very purpose of government itself, in an orderly but firm way, is to first ascertain what is necessary in the solution of any given problem of this character and then through the application of its police power, to adopt equitable rules and regulations to achieve the desired results.

Mr. ROBERTS You may proceed, Mr. Kennedy.

Mr. KENNEDY. May I hand also to the clerk copies of the report submitted to the Board of Supervisors of the County of Los Angeles, prepared by the legal counsel, entitled "Legal Support for Los Angeles County's Strict Air Pollution Control Program."

[1] For further legal references supporting the above principle, see Legal Support for Los Angeles County's Strict Air Pollution Control Program, by Harold W. Kennedy, county counsel of the county of Los Angeles, Calif., and legal counsel for the Air Pollution Control District of Los Angeles County; Municipalities and Law in Action, Kennedy, Air Pollution Control, National Institute of Municipal Law Officers, Washington, D. C., 1947; The Legal Aspects of Air Pollution Control, Kennedy, Southern California Law Review, vol. 27, p. 373, July 1954.

Reference will be made to it in my statement. I also wish to file a report which was filed and released just last Monday in the California Legislature entitled "Air Pollution and the Public Health," being Assembly Interim Committee Report No. 11, volume 9, 1955–57, filed by a special subcommittee of the California Legislature dealing with the relationship between air pollution and public health.

Mr. ROBERTS. Mr. Kennedy, do you wish these reports incorporated as part of the printed record or simply filed with the committee for reference?

Mr. KENNEDY. Probably filed and referred to. It would be rather extensive to include them in the full committee report. I recognize that.

Mr. ROBERTS. Very well. They will be filed with the committee for purposes of reference.

Mr. KENNEDY. I would like to state the official position of the county of Los Angeles with respect to the support of Congressman Schenck's bill. The board of supervisors adopted the following resolution, which I will read in part only:

Whereas motor-vehicle exhausts have been established as the principal cause of eye irritation, reduced visibility, and damage to growing vegetation, in the Los Angeles Basin, at the present time; and

Whereas all other significant sources of air pollution in this area already have been controlled or are now being controlled through rules and regulations enacted by the Board of Supervisors of the County of Los Angeles, having jurisdiction over the county and air-pollution control district; and

Whereas the control of motor-vehicle exhausts now constitutes the principal problem confronting the Los Angeles County air-pollution-control program and motor-vehicle exhausts are considered to be a problem in other metropolitan and urban areas of California and the Nation, combustion products contained in motor-vehicle exhausts being suspected as a serious hazard to the public health; and

Whereas the recently published findings of the assembly interim committee on public health of the California Legislature point to hydrocarbon emissions from motor vehicles as a very real hazard to the health and welfare of the residents of urban areas; and

Whereas H. R. 9368, introduced by Congressman Paul F. Schenck, of the 3d District of Ohio, now pending before the 1st session of the 85th Congress, would prohibit the use in commerce of any motor vehicle which discharges unburned hydrocarbons in an amount dangerous to human health, and calls upon the Surgeon General of the United States to be responsible for determining and publishing safe standards of hydrocarbon emissions from motor vehicles: Now, therefore, be it

Resolved, That the Air Pollution Control Board of Los Angeles County advise the California delegation in Congress to lend its support to the principals contained in H. R. 9368, regarding the establishment by Federal authorities of permissible hydrocarbon emission standards for motor vehicles.

In Los Angeles County during the past 9 years, we have had a considerable experience in connection with controlling air pollution. We believe we have gone a long way. During the 9-year period, by careful computation, there has been a very large amount of money paid out by the taxpayers in support of the air pollution control program.

To be exact, for the 9 years' experience the taxpayers of Los Angeles County have spent $10,600,000 in support of the Los Angeles County Air Pollution Control District. The budget for the district this last year was $4 million, with 128 employees. During this same 9-year period, 1948 through 1957, under the rulemaking power of the district, industry was required to invest in many types of control devices and spent for such purposes in the aggregate $49,900,000.

In addition to these two sums, research expenditures by other agencies in the Lost Angeles County area amounted to $12,500,000. Therefore, the staggering sum of $73 million has been expended through public and private funds in Los Angeles County, which documents a large measure of self-help in battling California's second most important problem.

I am mindful, of course, that in the committee room today there are important representatives from the great automobile industries of the United States, and I know, of course, that they will not be exactly happy with the statement that I am about to make.

Over the 9-year period in Los Angeles County, we have found that unless and until, by the adoption of a rule under the police power given to the district by the legislature, we fix standards, ascertain standards, and determine deadlines, that we did not make progress in the field of air-pollution control.

At the beginning, we tried a cooperative program, calling upon industry to make its contribution. While it would be unfair to say that industry has not now cooperated, in a very realistic way, that cooperation came after the technology had reached the place where it could support a rule, a definitive standard as to a certain type of air pollution.

Then a reasonable rule that would say to the oil industry, say to the steel industry, the gray-iron foundries, roof manufacturers, the furniture manufacturers, the manufacturers of roofing material and all types of industry, where inherent in the function there is air pollution, we found over this 9-year period that when we worked diligently on finding a standard, and adopted a rule, that at that juncture we received good cooperation.

So in connection with the polluting that comes from automobiles, we have in Los Angeles County registered between 2½ million and 3 million automobiles, burning millions and millions of gallons of gasoline. The scientific experts are almost in agreement that the major remaining source of air pollution in Los Angeles County comes from the hydrocarbon from automobiles.

Therefore, we believe that Congressman Schenck's bill, although it is stern in its terms, puts in sharp focus the need, not only in Los Angeles County, in San Francisco, in San Diego, and other urban areas in California, but also we believe that it will be helpful to every urbanized area in the Nation.

If, by its terms, as it calls upon the Surgeon General to ascertain those standards within 6 months, if that is not a realistic period, that is not in our concept too important.

The important thing is to make a start. The county of Los Angeles believes that it must turn to the Congress of the United States to employ its constitutional power, its police power, if you please, in order to define standards, fix rules, provide penalties, the effect of which will force, in many ways, the clearing of aerial sewage that comes from the exhausts of automobiles.

It would be presumptuous on my part to seek to testify as to the increasing pattern that is developing from the medical profession with respect to the close relationship between the automobile exhaust hydrocarbons and public health.

In that regard, because I wish to be very specific, I would like to turn to a portion of my report.

There is nothing that I could say which would put in sharp focus the need for affirmative action on the part of the Congress along the lines of Congressman Schenck's H. R. 9368 more than the official report of the Department of Public Health of the State of California the Clean Air Quarterly, published by the State of California, Department of Public Health, volume 2, No. 1, March of 1958.

This report has been prepared under the direction of Malcolm H. Merrill, M. D., director of public health of the State of California.

Mr. ROBERTS. What part of your statement are you referring to?

Mr. KENNEDY. That is a separate and distinct report, Congressman Roberts, to the one that I handed to you. That is the one that was filed last Monday with the California Legislature. This is an earlier report filed by the director of public health of the State of California.

The reference to that is found on page 6 of my prepared statement.

Mr. ROBERTS. Thank you very much.

Mr. KENNEDY (reading):

> Through its extensive control program, the Los Angeles County Air Pollution Control District has reduced the quantity of pollutants being discharged to the atmosphere, mostly because of a lack of known control methods it has not been able to control nitrogen-dioxide emissions from combustion sources and hydrocarbon from motor-vehicle exhaust. The Los Angeles County Air Pollution Control District has had an active enforcement program, and has reduced emissions to the atmosphere from many sources.
>
> Prospects for a further sharp reduction in air pollutants in Los Angeles are poor until a control device for motor-vehicle exhausts is available. Because adoption of regulations and installation of control devices take time, it will be a few years before pollutants from sources now under control in Los Angeles will be appreciably reduced in other parts of the State also.
>
> Research indicates that eye irritation and crop damage are related to automobile exhaust. Automobile exhaust is also known to be associated with the liberation into the atmosphere of substances which in the laboratory are known to cause cancer.
>
> It would be a tragic mistake to be content with the elimination of eye irritation only, to find in a decade that our populations had been exposed for years to cancer-producing substances in quantities capable of producing disease.
>
> By that time, preventive measures would be too late.

That is the end of the quoted statement from Dr. Merrill's report to the Public Health Service in California.

Specific attention is called to the source of these prognostications. They represent the studied and carefully weighed opinion of the Department of Public Health of the State of California, based upon years of research, and recognizing their heavy responsibility in not unduly alarming the public in their assertions that the automobile exhaust is also know to be associated with the liberation into the atmosphere of substances which, in the laboratory, are known to cause cancer.

I wish to make reference to one other point, and that is the legal support for a strict pollution control program. Some years ago, the Los Angeles County counsel's office had occasion to research the legal aspects of air pollution control, and to set out in this brochure those points.

There isn't any question at all that under the Supreme Court decisions of the United States, if and when a device has been perfected that, from the standpoint of the technologists, will control emissions from automobile exhausts, that, as a matter of constitutional law, such rules or regulations could be adopted by the Congress of the United

States, by a State legislature, or by any county or city having police power under its own constitution.

The Northwestern Laundry versus Des Moines case, passed on by the Court as early as 1916, is still the leading case in the United States.

In the statement which I have filed with the committee, there are 10 pages of legal citations which will buttress the legal conclusion that just as soon as such a device has been perfected, then it could be ordered as the Los Angeles County Board of Supervisors would like to order it at the earliest possible time.

You have been very patient, and I will make one more reference and then close. During the almost 10-year history of the pioneering efforts of the county of Los Angeles, and I am now referring to pages 18 and 19 of my statement, the county of Los Angeles, through its respective agencies, to, in good faith, measure up to the needs of the people in adequate and efficient air pollution control, it has been the policy of the Board of Supervisors of Los Angeles County to give full credit to the splendid cooperation which has been received generally from industry.

More than 5 years ago, the automotive industry and its executives and engineers were called upon to extend themselves in a genuine and realistic way to engage in a program of research, experimentation, and testing, to reduce hydrocarbon pollutants from automobiles, through improved engineering or a motor vehicle exhaust device, and for a time several million people in Los Angeles County believed that because of their vast financial resources, their great engineering skill, and because of the important part which motor vehicles play in the economy and life of America, that the automotive industry could enjoy the satisfaction of having furnished the leadership and the funds to develop the improvements needed. Some place in the record the assurance was given that when the 1958 models were in the showrooms, they would contain an air pollution control device.

1958 models do not have such control devices, and up to the present time, definite and specific assurances have not been forthcoming from those great industrial concerns whose business it is to produce motor vehicles.

It is the considered judgment of representatives from the county of Los Angeles that before real progress is made, it will be necessary for boards of supervisors and county commissioners under their rule-making power, State legislatures, and the Congress of the United States, to fix reasonable standards and outline reasonable deadlines in order that the health of the American people may be fully protected.

It must be remembered that in the long history of government, its primary purpose is to protect the people, and that the very purpose of government itself in an orderly but firm way is to first ascertain what is necessary in the solution of any given problem of this character, and then through the application of its police power to adopt equitable rules and regulations to achieve the desired result.

That, gentlemen of the committee, is the reason that the county of Los Angles is firmly in suport of Congressman Schenck's H. R. 9368. Thank you very much.

Mr. ROBERTS. Because of the fact that the gentleman from Ohio introduced this bill, and is doubtless more familiar with it than any

other member of the committee, the Chair is going to yield to him at this time to examine Mr. Kennedy.

May I also, Mr. Schenck, say that I note the presence of Mrs. Schenck in attendance at our subcommittee meeting. We are glad to have you, Mrs. Schenck.

The gentleman may proceed.

Mr. SCHENCK. Thank you very much, Mr. Chairman.

I am especially appreciative of the fine statement Mr. Kennedy has made, and also of his willingness to come here, this great distance, to testify on this important matter. I would like to point out for the record, Mr. Chairman, that Mr. Kennedy has a most unusual and distinguished background of experience.

He has an earned degree as a doctor of law. He has been highly recognized by many organizations for his splendid work. From the University of Southern California, Mr. Kennedy received his master's degree in science and public administration, and wrote a thesis on the legal aspects of air pollution. He has also been recently selected to present a paper, 50 Years of Air Pollution Law, at the 50th anniversary meeting of the Air Pollution Control Association of the United States, scheduled for June in St. Louis.

So Mr. Kennedy comes to us well qualified to present his views.

I would just like to ask Mr. Kennedy a question again.

Was it my understanding from your statement, Mr. Kennedy, that you feel that this type of legislation, and the results, merit its immediate starting at some point?

Mr. KENNEDY. Very definitely. It isn't just an idle opinion. For example, the Bethlehem Steel Corp. had some open hearth furnaces in the Los Angeles area. We tried for a long time to secure abatement through cooperative methods. It was not until we filed an abatement proceeding in the Federal court that we got the cooperation that was necessary. To their credit, they spent a very large amount of money, took out the open furnaces and put in electric precipitators. But the fact was we had to use the power of Government in order to effect that. I think you are going to have to do exactly that same thing in connection with the automobile exhausts.

Mr. SCHENCK. And you feel, Mr. Kennedy, that this is important from the standpoint of public health?

Mr. KENNEDY. I think you have rendered a great service to the country by setting up a sounding board, by setting the stage here for the people who are really qualified, the medical men and the scientists, to show that there is an increasing relationship between air pollution that comes from hydrocarbons from automobiles and public health.

These two reports that I have referred to in my statement, the one filed with the California Legislature and the one by Dr. Merrill, document the fact that there is a very close relationship from their clinical studies; some pathology has been engaged in and some laboratory experimentation on animals. There is a definite relationship between pollutants from automobiles and public health; yes. sir.

Mr. SCHENCK. Mr. Kennedy, I take it, then, from you very definite response that you feel the Public Health Service should not just shrug this thing off on the basis that an insufficient amount of scientific data is not now available, but that they should actively pursue the question and determine standards, that if the 6-month period is not sufficient

time in which to accomplish that, that, without detriment to the program, it should be extended to a longer period of time in order to establish standards.

Mr. KENNEDY. In my concept, it is within the framework of the responsibilities and the framework of the Public Health Service. I think they should embrace the opportunity to further be definitive in this important matter.

Mr. SCHENCK. Thank you very much.

Thank you, Mr. Chairman.

Mr. ROBERTS. Mr. Friedel.

Mr. FRIEDEL. Mr. Kennedy, I want to thank you for your very fine statement. There is no question but that you have done a lot of research and put in a lot of time studying this subject. Do you think by the passage of this bill it would eliminate all the smog or smoke control, or would it be confusing, bringing in smoke control and unburned hydrocarbons?

Mr. KENNEDY. I will limit my answer to the Los Angeles operation, and the California situation, because it is generally believed, not just the self-serving statement of representatives of the district, but as the public health report indicated, we have whipped almost everything else except hydrocarbons from automobiles, and also some pollutants still coming from the burning of fuel oil in some of the steam plants.

So, quantitatively, from the standpoint of the Los Angeles County Air Pollution Control District, this is the one last large remaining source. We believe that a bill having these principles—I am not sure that 6 months is enough to give the Surgeon General the opportunity to come up with something as a doctor he could support—these principles we support and we believe that while it is a pioneering approach at the level of the Congress, it is essential. So my answer is in the affirmative.

Mr. FRIEDEL. The reason I asked that question, is because we have smoke control in the city of Baltimore. I remember one big plant there, and there was a lot of smoke from their burning soft coal.

After we adopted the ordinance, they put in precipitators. While they had been getting 1 or 2 carloads of ash a month, they started getting 4 or 5 carloads a week after putting in precipitators. That is under the smoke control.

But getting back to the unburned hydrocarbons, do you have any trouble with low-grade diesel oil from trucks and motorbuses?

Mr. KENNEDY. Yes.

Mr. FRIEDEL. Are they allowed to use any grade at all?

Mr. KENNEDY. As far as grade, they are allowed to use any grade, but they are subject to being cited as in violation of one of the rules of the air pollution district if their emission is beyond a certain standard.

Mr. FRIEDEL. Would the elimination of the low grade and the burning of better diesel oil do away with the bad fumes that we have?

Mr. KENNEDY. Some. We are told by the operating people that if the diesel trucks are properly maintained, that also is a credit factor that is of importance. So we have gotten cooperation from management of the trucking industry to have better maintenance on diesels. So all of those things are contributive to a better result.

Mr. FRIEDEL. Getting back to the automobile industry, you find that your main trouble is with their exhausts, is that correct?

Mr. KENNEDY. Well, Dr. Campbell is here from the scientific team from the automotive industry. When they first came out a number of years ago, they were talking about either improved automotive engineering, improved carburetion, in the front end, or an afterburner, a catalytic type of device, that would treat the hydrocarbons as they come out from the exhaust. My understanding is, and there probably will be testimony also before the committee that is more accurate, that the thing they are most hopeful about is some type of an afterburner.

Mr. FRIEDEL. Thank you very much.

Mr. ROBERTS. Mr. Bush?

Mr. BUSH. Thank you, Mr. Chairman. I first want to say I am sorry I am late. I had another meeting to attend.

Mr. KENNEDY. You have made a very fine statement with reference to Mr. Schenck's bill. The thing that I am wondering is this: What are we going to do to control these exhaust gases? Do you have any suggestion as to how it is to be done. We know they have been working on some method to perfect some kind of a device to control these unburned gases for a quarter of a century? What is the answer to it?

Mr. KENNEDY. Congressman Bush, I think your question goes to the core of the matter. If my testimony has reflected a little frustration, I think it indicates that in this matter, we are almost wholly in the hands of the automotive engineers and the scientists. I think we have to look to them. That is why I am quite enthusiastic about Congressman Schenck's bill. I think even if it does crowd the automotive industry to do more, maybe, than they had planned to do, I think it accelerates the activities that they have already engaged in.

They spend millions and millions retooling for new designs, more horsepower, dual carburetion, all types of things.

Bigger and bigger tail fins. We would like to be sure, I would like to go back and assure the 6 million people in Los Angeles County that the automotive industry, from the testimony I hear at this session, is absolutely in good faith that they are doing every single thing they can.

Under my own study here, unless and until the device has been perfected, I do not believe that legal principles would support it.

I hope I am practical enough not to force the expenditure of $100 million by 3 million automobile owners to buy a gadget that turns out to be a flub. In other words, it is going to have to be something that will do the business. The only way it can be done is to first get it off the drawing boards, get it into research production, and tested out. Believe you me, when it is ready, the Board of Supervisors of Los Angeles County, to a man, will unanimously require its use on every automobile sold for use in Los Angeles County.

Mr. BUSH. I have a very strong feeling that everybody is interested in the elimination of unburned gases that are harmful to health. Practically all of the garages that I know anything about, where they repair automobiles, have exhaust outlets to which they have tubes attached which they put over the exhaust pipes to protect the men who are working on the cars in the garages.

Up until now I know of no device that has been perfected that will do just what we would all like to have done. I know of a lot of people who have tried to perfect some kind of a device that will accomplish just what all of us would like to see. But up until this present time, it just hasn't been accomplished. We can eliminate if we want to go back to the horse and buggy days, and do away with automobiles.

Mr. KENNEDY. That is impossible, of course, sir.

Mr. BUSH. That is impossible, and we do not want to do that. What kind of a suggestion, or what suggestion do you have——

Mr. SCHENCK. Mr. Chairman, if the gentleman will yield, may I point out that the purpose of this legislation is to ask the Surgeon General to establish standards, and as a result of those standards the very able and capable engineers and scientists in the automotive field could undoubtedly be encouraged to develop a device which would do it.

It isn't the purpose of this legislation to spell out the kind of a device or how it can be done, mechanically, scientifically, or otherwise, but merely that the standards by the Surgeon General encourage the engineers to come up with a proper answer within the time, within a reasonable time.

Isn't that true?

Mr. KENNEDY. That is true. In other words, this will speed up such a device. We have had a number of them submitted to the technicians of the district. One is reported to have tested out to being about 15 percent efficient. Where you use police power, it is a very potent thing, and those responsible for the application of police power must not be premature in their moves.

So we would not wish having one that was only 15 percent efficient, and then say "Everybody has to pay $50.75 or $100, and buy one of these devices."

But I am enthusaistic about the Congressman's bill, because I think it will speed up the application of the know-how that the automotive industry has, and will indicate to them another flag in the wind, that whatever plans they have with respect to this matter they better speed up because time is running out as far as the patience of people and government.

When you get reports such as I handed to you gentlemen this morning it becomes more important. This is not just an idea on my part. I filed with the clerk a copy of the Pasadena Independent of last Monday, March 10, "Smog Findings Held 'Shocking.' "

Dr. Breslow also testified that the mortality rate of lung cancer doubles every 10 years in California. That is not an off-the-cuff statement on my part, but it is quoting from Dr. Lester Breslow, chief of the State department of public health.

When a community of 6 million people, and California with 14 million people, is confronted with headlines like that, then we believe that our responsibility is to do every single thing we can. When you go back into the history of the law, you do not have to wait until pathologically X number of people have died from cancer.

When pathology indicates that some people might die from cancer because of pollutants from automobiles, then at that point government, under police power, has the right to throw a protective roadblock.

So we feel that the principles of the Congressman's bill get started on this very important matter.

Mr. ROBERTS. Would the gentleman like to offer that newspaper article for incorporation in the record?

Mr. KENNEDY. Yes, sir.

Mr. ROBERTS. Without objection, that may be done.

(The document referred to follows:)

[From the Independent, Pasadena, Calif., March 10, 1958]

SMOG FINDINGS HELD "SHOCKING"—POLLUTION BLAMED FOR HEART ILLS

Sacramento lawmakers yesterday released a report in which they reported "an apparent connection" between smog and an increase in heart disease and lung cancer in California.

Assemblyman Thomas M. Rees, Democrat, of Los Angeles, called the findings shocking and said the report "emphasizes the immediate need for more research of air pollution and more stringent laws for air-pollution abatement."

REES CHAIRMAN

Rees is chairman of an assembly public health subcommittee which released the findings based on testimony from outstanding medical authorities of both California and the Nation.

The subcommittee report quoted Dr. Lester Breslow, chief of the State department of public health's division of chronic diseases as saying that heart diseases now account for about one-third of all deaths in California.

MORTALITY RATE

Dr. Breslow also testified that the mortality rate of lung cancer doubles every 10 years in California.

The report stated that there was recent evidence that environmental factors—such as air pollution—not only are important contributors in the development of lung cancer but also in the increasing evidence of coronary diseases and resultant mortality.

It added that in California, mortality from lung cancer is higher than elsewhere in the Nation and that there is a greater mortality rate from this disease in urban than in rural areas.

HITS LUNGS

The subcommittee quoted Dr. Paul Kotin of the University of Southern California medical school as stating that irritants in smog interfere with the ability of the lung lining to clean itself or move the particles along the lining of the bronchial tubes.

Dr. Kotin said he believes that these interferences with the natural pulmonary defense mechanisms are contributory to the formation of cancer by permitting the suspected cancer-producing pollutants to deposit themselves on the linings and remain there to do their damage.

Mr. BUSH. Mr. Chairman, I have a couple more questions.

Mr. ROBERTS. Mr. Bush.

Mr. BUSH. One thing I am well aware is that the purpose of this bill is for the Surgeon General to set up certain standards. If he does that, and we have no device to meet those standards I would like to know what position we are in then.

Mr. KENNEDY. I think the first part of the bill could be operable. In other words, certainly progress is made by having the Surgeon General definitively ascertain the standards. In other words, how much hydrocarbon can a human being absorb and still not become violently ill or become subject to impaired health. Certainly that does no harm. Then that might—and I think your question points out the logic of the matter—then necessitate a further deadline as to when the penalty is invoked. I recognize that.

But I think you have to make a start, at least on the first part of the bill, and the Surgeon General is certainly the logical person, that is the logical agency, to have the responsibility for doing this.

The Surgeon General has already granted, as originally requested by the county of Los Angeles, a national symposium on air pollution, to act as an educational medium to inform the American people of what steps have been made in air pollution control. Very fine plans have been made for such a program in November. So in my belief, it is entirely within the scope of the activities given to the Department of Health, Education, and Welfare.

Mr. BUSH. We appreciate the seriousness as far as these unburned gases are concerned in heavily populated areas, where there is a concentration of movement of traffic. Certainly the effect is much greater in localities such as those than it is out in the open spaces. We can all appreciate that. I know the automobile engineers, the automobile companies, and bus and truck companies, are very much interested in getting some kind of a device that they can control, at least to a great measure, these unburned gases. They are much interested in that.

Mr. KENNEDY. I am sure they are. The people in Los Angeles want to be sure that they are not dragging their feet, and that they are doing every single thing that they can.

Mr. BUSH. This gadget that we speak of could very well come from outside the automotive engineers' research and their own development. There has been a lot of thought and a lot of study on this very thing. I know when an automobile gets older, there is going to be more of it exhausted into the air. You have those conditions which certainly have to be met locally. But the thing that is puzzling me is how we are going to get this device.

Somebody has to be pushed into the corner to develop that device. Nobody has come up with it yet, and yet they have been trying for a quarter of a century.

Mr. KENNEDY. I think there are witnesses waiting to be heard who will tell you that they have made some progress in connection with such a device.

Mr. BUSH. It has not been part of the automobile equipment as of now.

They have better carburetion and all that, to burn up the gases better, with higher compression ratios and all of that kind of thing, which all help to burn up the gas. But there is still a certain amount of harmful gas that is concentrated in an area. I want to thank you for your statements. I know I, for one, am very much interested in it because the health of our people is certainly paramount in everyone's mind.

Thank you, Mr. Chairman.

Mr. ROBERTS. The gentleman from Tennessee?

Mr. LOSER. Mr. Kennedy, I have not had an opportunity, of course, to read your brief on legal support for the program of your county, and your statement. You have testified orally here and I do not know just what is included. Therefore, I am just a little bit in the dark. But I would like to ask a few questions on the legal phase of it, as I am interested in that direction as well as in any effort that the Congress can make, legally, toward the assisting of Los Angeles County

and other areas in the Nation where there is the situation that you have decribed.

I notice your brief starts out with "To most of us, 50 years seems a very long time," and it refers to developments and magnificent advances in most material spheres of man's endeavors. Then you go right into the police power of the States and of the Nation. Of course, from time immemorial what we lawyers know as a common-law nuisance has been not only a tort but a crime under the common law of England.

Your brief, I take it, begins at that point and comes on down through the years where the several courts of the Nation have passed upon certain situations and have declared them to be public nuisances.

Mr. KENNEDY. Yes, sir.

Mr. LOSER. And you are taking the position in this brief that the situation in your county is a common-law nuisance; is that right?

Mr. KENNEDY. Well, we could ground it on that, but we have put it on firmer ground, because in California, under section 11 of the California constitution, a county has police power, and when we drafted the 1947 air pollution control district, we specifically picked up the fiat of police power that the legislature could give the countywide air pollution control district. So we grounded it not upon the common-law theory of a nuisance, per se, but a prohibition passed by government under police power. Pursuant to that prohibitive authority, flowing from the California constitution, we have, in the 9 years, adopted a whole series of rules at public hearings, after due process and notice, about 50 of them, in 1 type of pollutant after another, dealing specifically with the quantitative standards. That is the legal approach that we have taken.

Mr. LOSER. Do the counties in California, under your constitution have police power?

Mr. KENNEDY. Yes; they do. But it is applicable only in the unincorporated territory.

Mr. LOSER. But your cities do have police power inherently; do they not?

Mr. KENNEDY. They have it in California under the same section of the constitution. They are on a parity with counties, but, you see, in a practical way from the standpoint of administration, recognizing that smog does not stop at boundary lines, we had to have a power that was coterminus with the boundaries of the county. So we got it through this 1947 act which gave the police power to the district, countywide, and that put us in an efficient administrative position.

Mr. LOSER. I was wondering if you folks out there distinguish between smog and unburned gases.

Mr. KENNEDY. We started with all types of pollutants. That is, first with the visible ones. There is a very fine engineer in the room here today, Mr. Gordon Larson, now with a firm in Pennsylvania, who was one of our first air pollution control directors, who did a great deal in removing sulfur, for example, and who got fine results in 10 or 15 different types of pollutants. To answer your question specifically, our act embraces not only visible pollutants, not only particular matter, but gases, invisible gases, as well.

Mr. LOSER. I am, of course, interested in the question, but I am just wondering about whether it is possible, or whether an effort has been

made, or whether there has been any success if an effort has been made, to distinguish between the smog that you have in California and unburned gases from automobiles.

Mr. KENNEDY. Efforts have been made, and considerable progress has been made.

Mr. LOSER. You say considerable progress. You are not able to pinpoint what the unburned gases are doing in your area without reference to smog?

Mr. KENNEDY. Well, of course, it would be presumptuous for me to say, with accuracy, that you could absolutely measure, because it is the type of a problem where everything goes into the air, where you have an inversion weather condition with a ceiling of cold air holding the pollutants close to the earth, with the testimony of the scientist that there is a chemical intersection as between one pollutant and another. It gets to be pretty complicated. It would be a little out of my field to give the chemical formula.

Mr. LOSER. I understand very well the difficulty you are having out there, and the problem. But I am wondering whether or not the Congress of the United States is empowtred to legislate in a field that is so highly speculative. You understand, of course, that we are bound by the commerce clause of the Federal Constitution. Unless we can show that this device that you are talking about is directly connected with interstate commerce, the legislation would be invalid.

Mr. KENNEDY. I agree as a matter of law that would be true. My aswer to you is that most experts are in agreement that there is enough scientific evidence upon which to ground a reasonable rule with respect to the contribution that automobile exhausts are making to the atmosphere. My answer is in the affirmative.

Mr. LOSER. Of course, you understand that in the law of torts that would be wholly insufficient, where no contribution between joint wrongdoers and in that category, if you can't pinpoint what the automobile is doing and what somebody else is doing, and what the atmosphere is doing, you could not recover in tort law; could you?

Mr. KENNEDY. I think as I understand case law in the field of air pollution, set out in this memorandum, if three well-qualified doctors testified that in their opinion, based upon such studies as Dr. Mills, of Cincinnati, has made, based upon the very specific findings in the assembly interim committee report that you have before you, that some people are having their health impaired because of the fumes from automobile exhaust, that we could pass a reasonable rule that would stand the test.

One of the oil companies took us to the Supreme Court of the United States on a writ of certiorari to declare our act unconstitutional. We happily survived. We have tried not to, ahead of the technology, adopt a rule, but we have been able to sustain approximately 50 rules that we have applied. We believe, the county of Los Angeles believes, my board of supervisors believes, that the place is rapidly approaching where such a finding could be made.

I still say in answer to your question, and as I have set forth here, that you could not order a device—it would not be reasonable to say you cannot discharge more than X quantity of hydrocarbons, unless there was available to the auto owner a device.

I do not think the law would punish a man or put him in jail for driving a car that did that unless there was a device. That is why, in effect, we must petition the automobile industry and others to come forward with such a device.

Mr. LOSER. That leads me to my next question, and that was the thought that I had in mind. Really, what you are doing is, and it is a worthwhile effort, pleading with the automobile manufacturers of the Nation to develop a device whereby the people of the country will be relieved from these unburned gases.

Mr. KENNEDY. Yes.

Mr. LOSER. That is in effect what you want.

Mr. KENNEDY. That is right. I am willing to use the word "plead," and I know that the great metropolitan area of Los Angeles will be very grateful as well as other cities in the country.

Mr. LOSER. I am sure they would. But you are too great a lawyer to say that the police power of the Nation can be invoked to require the automobile people to develop a device that nobody knows anything about at the present time.

Mr. KENNEDY. Yes; I think that would not be feasible.

Mr. LOSER. I just noticed here in this air pollution and public health committee's conclusions, No. 1:

> There is at present insufficient data on what constitutes our California smog, on the specific components of smog and the interaction between these components. Because of this lack of knowledge, it is impossible to establish specific criteria concerning the effect of air pollution on health.

That is the No. 1 finding of your committee.

Mr. KENNEDY. That is right. But that still doesn't mean, Congressman, that the Surgeon General couldn't possibly furnish strong leadership in ascertaining that standard. In other words, maybe they haven't done well enough out in California. Maybe he can.

Mr. LOSER. I thoroughly agree with you that the Surgeon General of the United States is a great official, and that he will make great contributions to what you have in mind. But I would not want to close my examination without stating to you that I do not believe that you mean that that paper, the shocking finding of smog, can be attributed to the automobiles in the area.

I am referring to the news article you submitted.

Mr. KENNEDY. The news article suggests that the prime source is automobiles. Of course, I would not put in evidence as a scientific document such a paper.

Mr. LOSER. I want you to understand that I appreciate your presence here. I am interested in the legal questions involved as well as the public health of the Nation. I am hopeful that the automobile people might develop means whereby these unburned gases can be burned. I would like for them to also take up the question of servicing these cars before they leave the factory, because we have considerable trouble with them at my house.

Mr. KENNEDY. Thank you.

Mr. LOSER. Thank you.

Mr. ROBERTS. I want to thank the gentleman, Mr. Kennedy, for a very fine statement.

Our next witness will be Dr. Robert Zipf, director of research, Miami Valley Hospital, Dayton, Ohio.

Let me say to the gentlemen on the subcommittee I appreciate your interest, and I do not want to foreclose questioning, but we do have a lengthy list of witnesses here, and I would appreciate very much if you would try to cooperate with the Chair in being as brief as you can.

No one is being singled out. Everyone is equally guilty.

STATEMENT OF DR. ROBERT ZIPF, DIRECTOR OF RESEARCH, MIAMI VALLEY HOSPITAL, DAYTON, OHIO

Dr. ZIPF. Honorable sir, I am very happy to be here this morning. I would like to take this opportunity to congratulate your committee and Mr. Schenck on the vision you have used in the preparation of this bill. I have no prepared statement, due to prior obligations.

Therefore, I shall make my comments from notes I have at hand. I trust they will be short and concise.

The bill H. R. 9368 makes reference to hydrocarbons specifically with reference to carcinogenic nature of unburned hydrocarbons.

The knowledge of the medical profession, knowing that there are somewhere between 600 and 800 or 900 or even 1,000 types of chemicals that will produce cancer, it is difficult at this time to probably delineate any specific hydrocarbon as a causal relationship in the production of cancer.

I think there probably is some other causal relationship which may be demonstrated at a later date that unburned hydrocarbons may be implicated in other types of respiratory details or chronic diseases of the aged. I think one of the most important factors about the bill, which is not too clearly outlined, is the possibility or probability of carbon monoxide which is not specifically mentioned, because I think this is one of the important facts in the cause of traffic accidents and certainly in many deaths, not only in our community but communities over the United States. We are well aware of the poisonous nature of carbon monoxide, and this possibly may be one of the more specific things that could be examined rather than the more nebulous situation of carcinogenesis.

I think the bill states that minimum standards would be established by the Surgeon General in a period of 6 months. That is somewhat ambitious. I do not feel that any research organization will be able to establish minimum standards in this short period of time. I think to demonstrate this, the Atomic Energy Commission with a large amount of research in th demonstration of the innate hazards of radiant energy is to this date still attempting to establish minimal standards for the amount of radiation an individual should have over a period of days, week, or years.

Of certainty, minimal standards must be established. I think this is the encouraging part about House bill H. R. 9368, that there is an attempt to establish minimal standards. How minimal they may be, of course, depends upon the activities of the research organizations and the Surgeon General.

I notice that in the bill there is not mentioned the potential hazard of hydrocarbons or other materials that may exude from exhaust systems from railroad vehicles. The term "motor vehicle" is mentioned. It is not clear in my mind whether or not this does include the railroad

trains, for instance, which also exude a large amount of hydrocarbons.

I think there are other areas in which the bill could be expanded that in the future may be just as important as the hydrocarbons.

I am thinking now of the possible use of nuclear energy and nuclear propulsion in days to come, as to what effect this would have upon our population should this occur.

It may be possible that this should be included in our thinking when we are considering this type of bill for over a long period of time.

The bill certainly has much merit. I do not think the entire challenge can be made upon the automotive industry, but I think the bill merely points out that minimal standards should be established, and these minimal standards may be what we will accept today. They may not change our situation at all. In 5 or 10 years the situation may be different.

The honorable Congressman, I think, asked what method was there by which we could alter this, preventing the putting into the atmosphere of unburned carbons. I would like to mention offhand that it would be necessary to determine or establish a revolutionary method of motivation not requiring the internal combustion engine. I am sure our automotive industries are thinking somewhere along this line. But I don't think personally that the hydrocarbon problem will be with us always. It seems that this bill offers the potential of not only establishing a minimum standard but also a steppingstone by which other procedures or other bills could be established to give greater protection to our public.

I would like to mention the few points where I feel these expansions could take place. One, I think, we could expand it into agents other than hydrocarbons. There are certain noxious gases and materials, and they do not necessarily need to be gases, but other materials, which may be exuded from the exhaust system which are not hydrocarbons and may be just as detrimental to health as any other type of noxious agent.

Again I place before you the possibility of a waste product that may be from some type of nuclear energy or nuclear propulsion in the future. Another primary fine point is that this does stimulate research in the field of cancer in respect to the unburned hydrocarbons. I am certain that out of this, if we obtain no other information, specifically directed to the hydrocarbon, we will certainly find out some other aspects of cancer which would have not come to light had this type of investigation not been instituted.

In conclusion, I feel that the bill has many merits. I have suggested that it could be expanded, for the reasons stated, and under the aspects of the bill I feel that it should be considered favorably by our committee.

Mr. ROBERTS. Thank you, Dr. Zipf. I again want to thank you for appearing before our subcommittee. I remember that you made a very fine contribution along with the other members of your team when the subcommittee visited the city of Dayton, Ohio, which is the hometown of our colleague, Mr. Schenck. I was quite impressed then with your presentation, and I am again impressed today.

I have just 1 or 2 questions. Do you know of any instances where death may have been caused by carbon monoxide or other noxious gases coming from the exhaust of automobiles or trucks?

Dr. ZIPF. I have no experience in a direct causal relationship. We have experienced situations in drivers of vehicles in our area, which we feel have been under the influence of carbon monoxide while traveling in traffic in closed vehicles. This is not substantiated at this point by scientific evidence, and certainly needs clarification. But the potential as I see it is not so much from the direct cause of death from monoxide itself, as from the depression that would arise from minute amounts of carbon monoxide that may be in a car, either from the outside atmosphere exuding from an automobile in front of the car traveling behind, or from a leaky exhaust system within the automobile.

Mr. ROBERTS. If I remember correctly, and I would not state this as a fact, it seems to me that perhaps during World War II there were some instances where drivers of vehicles in rather long convoys died while driving, and there was at that time, I think, some thought that perhaps some of those deaths were caused by carbon monoxide from the vehicle ahead. I do not know whether you recall any of those instances or not, but I do seem to remember that at that time there were some statements in the press. As I say, I am not saying it as a fact.

Dr. ZIPF. This is very true. The monoxide problem is considerable. In our working relationship with the Air Force, we are working with them in detecting small quantities of carbon monoxide in accidents that may arise in aircraft. I do not know what their answers are at the present time, nor would I be able to reveal them if I did. But I do know that this is a problem not only in our automotive or driving, but also in aircraft travel.

Mr. ROBERTS. I believe that is all I had.

Mr. Bush, do you have any questions?

Mr. BUSH. I just want to say that you made a wonderful contribution this morning in furnishing this committee with opinions, which have a great bearing on the subject of unburned gases. I thank you for giving your time and appearing before us.

Dr. ZIPF. Thank you.

Mr. ROBERTS. The gentleman from Tennessee?

Mr. LOSER. I do not have any questions, Mr. Chairman.

Mr. ROBERTS. The gentleman from Ohio.

Mr. SCHENCK. Mr. Chairman, I just want to take this opportunity to express my grateful appreciation to Dr. Zipf for coming here, and also to express my pride in the fact that Dr. Zipf is not only an extremely highly qualified and widely recognized pathologist, but is a scientist who is working with the Atomic Energy Commission in addition to his own research laboratory, and who has made a great contribution to our own community of Dayton, Ohio.

I am particularly happy that he pointed out, though not in these figures, that today we have some 76 million automobiles registered and operating on the highways, and that illnesses can come about as a result of close traffic, congested traffic, in addition to these carcinogenic possibilities.

I am particularly happy and proud to have Dr. Zipf here, and I think it also ought to be shown that his very charming and helping wife is here with him.

Mr. ROBERTS. We are delighted to have her present today.

Mr. LOSER. Mr. Chairman, let me say to the doctor and other folks

from Ohio, that Ohio is indeed fortunate, Dayton specifically, in having such a splendid Representative in the Congress of the United States. He is greatly admired and respected by his colleagues for his great effort in the interest of his people.

Mr. SCHENCK. Thank you.

Mr. ROBERTS. I would like to say to the gentleman from Tennessee that I am sure there would be no objection to that being made a part of the record.

Thank you, Mr. Zipf.

The next witness is Mr. Charles Heinen, chairman of the vehicle combustion products committee, Automobile Manufacturers' Association, Detroit, Mich.

STATEMENT OF CHARLES M. HEINEN, CHAIRMAN, VEHICLE COMBUSTION PRODUCTS COMMITTEE, AUTOMOBILE MANUFACTURERS' ASSOCIATION, DETROIT, MICH.; ACCOMPANIED BY JAMES CHANDLER, VICE CHAIRMAN, VEHICLE COMBUSTION PRODUCTS COMMITTEE

Mr. HEINEN. As your Chairman Roberts pointed out, I am the chairman of the vehicle combustion production committee of the Automobile Manufacturers Association, which has been assigned the responsibility for the past 4½ years of conducting an intensive cooperative research and development program dealing with all aspects of the automobile exhaust problem, but particularly the phenomenon known as Los Angeles smog.

This special industry committee has representation from each of the major companies. Its membership includes James M. Chandler and A. L. Haynes, of Ford Motor Co., who is vice chairman, John M. Campbell, of General Motors Corp., Wallace S. Berry, of American Motors Corp., and George E. Onishi, of Studebaker-Packard Motors, appearing here today.

It does its work largely through technical panels or subcommittees and through the coordinating research council, a cooperative technical group comprised of automotive and petroleum technical personnel.

Aside from this committee activity, my professional responsibilities with Chrysler Corp. involve engineering aspects of materials. My particular specialization has been in areas relating to chemical engineering, which includes fuels and lubricants, plating, waste disposal, and so forth.

In addition, I am chairman of the Coordinating Research Council's group on composition of exhaust gases.

Our industry committee is pleased to be able to provide some information to your committee, Chairman Roberts, with respect to H. R. 9368 which pertains to the discharge of unburned hydrocarbons in motor vehicle exhausts.

CONSULTATION ON HEALTH ASPECTS

As part of the engineering consideration of the problem of reducing or eliminating all undesirable components of the exhaust, we have consulted with some of the specialists concerned with health aspects. These have included the United States Public Health Serv-

ice, the Los Angeles County Medical Association's committee on air pollution, and our own company medical directors in the automobile industry.

We sought information, first because we have regarded it as important to acquaint ourselves with whatever knowledge the medical profession might have in these areas and, secondly, because precise knowledge of possible medical effects of particular components of the exhaust would have helped to direct our research and engineering efforts into the more important channels leading to ultimate solutions.

During our investigations we became familiar with some published medical reports which indicated some possibility that unburned hydrocarbons, or the products of their reactions in the atmosphere, might produce carcinogenic effects or other undesirable physiological effects.

So far as we can determine, through our consultations, the medical profession has not verified or pinpointed any information of the sort. Fortunately, this has had no adverse effect on our research and engineering program because we have set for ourselves the overall objective of cleaning up the exhaust stream as completely as possible to remove any causes of irritation or annoyance, regardless of possible health effects.

LONG-TERM INDUSTRY ENGINEERING ON EXHAUST CONTROL

Motor-vehicle powerplants make use of fuels which are chemically very complex. As a matter of fact, ordinary gasoline has been said by one authority to defy any but the most superficial analysis. By this he meant, I am sure, that a complete analysis and the listing of many scores of chemical combinations and structures would be required to define a particular gasoline precisely. The problem is further complicated by the fact that exhaust contains many chemical combinations not in the original gasoline.

For more than half a century the motor-vehicle industry has had as an objective the reduction of undesirable exhaust emissions, including smoke, vapors, odors, and carbon monoxide. By the very nature of these programs they have been aimed in a direction that would reduce all hydrocarbons—which may well be defined at this point as representing invisible emissions, sometimes, but not always, accompanied by odors.

In 1953 the industry undertook an intensified program to find out more about the invisible hydrocarbon emissions because it appeared that they were changed in a photochemical reaction taking place in the bright sunlight of the Los Angeles atmosphere under some atmospheric conditions to produce characteristic concentrations of oxidants. These oxidants were indicated by research as the cause of eyesmarting, reduction in visibility, and plant damage.

The results of the studies to date by the automotive industry, the Los Angeles Air Pollution Control District, the Air Pollution Foundation, and numerous other scientific organizations have been published and discussed in many scientific meetings. We will be happy to discuss any of our reports with your committee.

RESEARCH RESULTS BEARING ON THE PURPOSE OF H. R. 9368

For the purposes of assisting your committee today, however, we will attempt to discuss three phases of knowledge which have a bearing on the requirements in H. R. 9368 for establishing standards and controlling the amount of unburned hydrocarbons in motor vehicle exhaust.

The three aspects on which we should like to offer some information are those concerned with—

A. Instrumentation and measurement of exhaust constituents.

B. Cycles of engine operation in vehicles under typical operating conditions, and their effects on the amount and concentration of unburned hydrocarbons in the exhaust.

C. Factors aside from operating cycles which have material effects on the amount of hydrocarbon emissions.

A. Instrumentation and measurement: Until the industry became concerned with the more intimate and detailed analysis of the exhaust stream, instrumentation used was not much different from that employed in studying any other products of combustion, such as those from a furnace or powerplant. In a broad way this kind of instrumentation sufficed because it was generally known that the unburned portion of the fuel supplied to the automobile engine was a very small percentage of the total.

However, when chemists developed information that the Los Angeles smog reaction involved such dilute concentrations as just a few parts per million in the atmosphere, it became necessary for the automotive engineer to find a way to sample the exhaust with instrumentation that would give him readings on these small percentages.

At an early stage of our investigation it became apparent that the exhaust stream is constantly changing, in terms of the total amounts of exhaust, concentrations of hydrocarbons in the exhaust, and composition of the ingredients which compose the hydrocarbon content of the exhaust.

As a result of our studies, instrumentation was developed to analyze more accurately the amounts of total hydrocarbons in the exhaust stream. Unfortunately, we have not yet resolved the problem of evaluating the individual constituents which compose this constantly changing stream.

However, for the engineering objective of reducing total hydrocarbons, a very large step has been taken by the development of the present instrumentation.

In the future in order to study the smog-producing potential of individual constituents of exhaust, or to ascertain health effects with some degree of precision, means will be required to evaluate specific components in the exhaust stream. A good deal of work is going on to develop such methods, but at the present time analytical knowledge is not sufficiently advanced to provide instrumentation to meet all the needs of either chemists or medical men.

The instrumentation that has been achieved for the analysis of automobile exhaust gases ranges from simple gas analyzers used in service stations to very complex research tools.

The service-station analyzer gives only a relative measure of the completeness of combustion in terms of carbon monoxide, but it will

not detect hydrocarbons or other constituents about which there might be particular concern. The more advanced instrumentation available to date includes—

1. An instrument known as a nondispersive infrared analyzer which gives a record of the quantities of hydrocarbons in the exhaust stream.
2. Mass spectrometers and dispersive infrared analyzers which give better differentiation, and break down the total amount of hydrocarbons into specific groups.
3. Gas chromatography, which takes these specific groups and breaks them down even further into smaller subdivisions.

Unfortunately, these methods which serve to identify the hydrocarbon materials make use of complex laboratory types of equipment not suitable for routine inspection of the nature of the exhaust stream.

As a matter of fact, all of these instruments are still in the latter stages of development and refinement as laboratory tools. For example, one of the projects jointly sponsored by the industry and others is a study within the Bureau of Mines devoted to gas chromatography methods.

Thus, while science has produced some new and fantastically sensitive methods of analyzing exhaust gas, these are not generally applicable for routine control purposes.

B. Cycles of operation: As the motor vehicle is driven on the streets and highways, it must be accelerated and decelerated frequently. Sometimes it idles for a length of time as a result of traffic or other situations. Part of the time it cruises along more or less steadily. This cycle of operations varies widely with the traffic situation and individual driver habits.

Each of the cycles of operation produces various concentrations and amounts of exhaust products. The most intensive study of this subject ever conducted has been made in recent years in the Los Angeles area.

For the typical conditions in that city the engine idles about 15 percent of the time, accelerates about 36.7 percent of the time, cruises about 16 percent of the time, and decelerates about 32.3 percent of the time.

During idle, the total output of hydrocarbons in terms of pounds per hour averages 0.16. The average for cruise is about 0.44. The average for acceleration is about 0.76, and the average for deceleration is approximately 0.36. Thus it is apparent that the rate of hydrocarbon emissions in the driving cycles varies by nearly 5 to 1 between the idle and acceleration conditions.

The concentrations of hydrocarbons in these cycles, in terms of parts per mission, vary by more than 10 to 1. Moreover, the composition of the hydrocarbons is different for every small change in speed, engine temperature, type of fuel, etc., thus posing a fantastic analytical problem, if an answer is to be stated in terms of types and amounts of hydrocarbons.

C. Maintenance factor: What this report provides thus far is only average figures. Actually the variation of hydrocarbon emissions is such that major differences in total concentration can be expected from different cars, depending in large measure on engine tuning and on the kind of maintenance they have had.

For example, a severely fouled set of spark plugs has been found to produce more than three times as much hydrocarbon emission in a

single vehicle during acceleration as a new set of spark plugs. Under city driving conditions, the average motorist often has some difficulty in detecting spark plug fouling.

This maintenance condition changes with sufficient frequency to constitute a major problem in characterizing the "average exhaust output" of any given car.

In view of the complexity of the problems associated with automobile exhaust, it is apparent why the initial efforts at control from the engineering viewpoint have been directed at finding some means for an overall, or gross, cleanup of these small but undesirable exhaust constituents.

INDUSTRY COMMITTEE OPINION ON FEASIBILITY

As you witness I have attempted to confine myself to outlining the present state of knowledge in this technical field, including the lack of definitive information on health aspects, and the intensive work which the engineers are doing to provide more adequate instrumentation, measurement and control.

I have also cited the wide variation of hydrocarbon emissions due to operating cycles and maintenance factors, and the chemical complexity of the exhaust products.

The industry's vehicle combustion products committee has given careful consideration to the intent and purpose of H. R. 9368 and believes that, because of the reasons outlined in our testimony, it could not be implemented effectively.

I concur with the previous witnesses that Representative Schenck has done a favor in bringing up the subject matter of his bill. I, too, am a citizen, a father, and have the best interest of my family and of myself at heart, from the point of view of health considerations. I can assure you that the whole committee, our particular committee, and the 100 or so people that are associated with its various subcommittees, feel equally, and that we are putting out what we consider a major effort in the area of this particular problem.

For the reasons which I have outlined in this written testimony, however, I would like to reread the conclusion.

The industry's vehicle combustion products committee has given careful consideration to the intent and purpose of H. R. 9368, and believes, that, because of the reasons outlined in the testimony, it could not be implemented effectively.

This is not to say the objectives are not very good, but that the bill itself cannot be implemented effectively.

I had expected to discuss only the specific bill and the specific language. But I find that in the earlier testimony the whole general question of pollution, particularly as applied to the Los Angeles problem, has come up. So instead of a 10-minute reading here, I wonder, Mr. Roberts, if you would be interested in seeing approximately a 30-minute presentation on slides, which we have, outlining the Los Angeles problem, which we consider to be the major problem area associated with the whole question of hydrocarbons, and some of the steps that the automobile industry has taken to establish data in this most complicated area and the steps that they are taking to try to do something.

I could only say try to do something, about developing a control device. We have made some progress.

Mr. ROBERTS. Let me say to the gentleman that I appreciate very much his kind offer. I know the committee would be greatly benefited by it. But at this time we are going to be pressed to receive testimony from some of the out-of-town witnesses who can only be here today.

It may be possible that I will be able to obtain unanimous consent from the House today for this committee to sit this afternoon. I am going to try to run as late as I possibly can. If we get through with the gentlemen who cannot be with us tomorrow, we will be certainly happy to see those slides. But I think at this time we will stick to the written statements.

Mr. HEINEN. If that is the case, then, you have the prepared statement. I would like to just summarize. Although previous witnesses have already pointed it out, I would like to emphasize the tremendous number of organic materials that are present in, say, a mixture such as gasoline, or a mixture such as the exhaust from the tail pipe. The previous witnesses indicated approximately 1,000 carcinogens. Just one of the compounds, and the very simplest one present in exhaust will produce approximately 90 of those carcinogens. Now, I want to emphasize that this is not peculiar to the automobile exhaust alone. It is true of any combustion process. Any incomplete combustion, and I don't care what it is, starting from your pocket lighter and going through to your powerhouses, any incomplete combustion will yield carcinogens. The yielding of carcinogens does not necessarily lead to a conclusion that cancer or other adverse medical results will occur, as far as we have been able to determine from rather substantial consultation with medical men.

I note, incidentally, that even Dr. Merrill is very cautious in his statement. He says that in the laboratory it has been shown that carcinogens, and this is only a rough quotation from memory, can be developed. I would like to supplement that statement by saying that carcinogens can be developed in any incomplete combustion.

Mr. Sherman has just brought me a stack of literature which represents some of the technical publications that we have issued as a result of our work.

It will bring out the immense complexities of doing the job that you wish, and rightly so, Mr. Schenck, if it could be done, that you wish done. I think in the interest of conserving time, unless you gentlemen have some questions, I think probably we will be around for another day or so and perhaps you would care to bring us back if you have further questions.

Mr. ROBERTS. Mr. Heinen, I think we will go ahead with some questions now. If we have time this afternoon, we certainly will be glad to see what industry is doing with your slide presentation.

Mr. Schenck?

Mr. SCHENCK. Mr. Chairman, I just would like to say this to Mr. Heinen and his fine group: When our committee was in Detroit a year ago, we had an opportunity to see some of the laboratory work that was being done by the outstanding laboratories in the country, and the world. One of the tests being run at that time was on an analysis of the exhaust gas shown on an analyzer connected to a

paper tape. It showed that, as the car was accelerated quickly, the amount of unburned gasoline was greatly increased from the tailpipe; that, as it decelerated, the amount was greatly increased.

At my request, the engineers operating that machine pressed down on the accelerator and let it up quickly, as some folks are wont to do at a traffic light or at a stop street.

It showed conclusively that at those times the amount of unburned gasoline put out of the exhaust pipe was greatly increased. That is a matter that can be controlled greatly by the driver himself. It is my hope that, included in the new releases, and in the work of your committee, and in the comments of various commentators, an educational program can be encouraged to influence folks not to make quick stops and quick starts, or to pump their accelerators at traffic lights, because of the health hazard.

I hope you will do what you can to encourage that type of public education.

Mr. HEINEN. We certainly will, sir. Indeed, we have done some of that, as has Mr. Griswold, from Los Angles, who I believe I saw in the room earlier. I might mention that we have gone even further than that. We have developed some devices based on the principle of reducing the unburned material during deceleration. Unfortunately, this amounts to perhaps 20 percent of the total amount emitted, and it is a very good question whether it is worth going after that 20 percent, not from our point of view but from the point of view of the administrators. Nonetheless, we have devoted, I would say, very substantial effort in that area, over the last 3 years, and have devices that we consider reasonably drivable at the present time. However, that only gets to part of the problem. It is an area where we could make a contribution, and where we have made a contribution.

Mr. SCHENCK. The industry is also, I believe, making changes in their ventilating systems in cars, so as to avoid some of that quick exhaust gas coming in from the car immediately ahead.

Mr. HEINEN. Yes. You are talking about the air intakes.

Mr. SCHENCK. Yes.

Mr. HEINEN. Yes; that touches on a different problem, slightly. I do want to emphasize that we are interested in removing hydrocarbons, particularly in Los Angeles, regardless of carcinogenesis effects not of the material as it comes out of the tailpipe as you would find it in this fair city, but the reaction that occurs in the more or less quiet Los Angeles atmosphere with their far-famed sunshine. So we keep working, regardless of whether anybody finds any carcinogenic reactions. But at the present time, just for the information of the committee, I have been unable to find anybody who was brave enough to stick out their chin to the extent of saying that there are specific carcinogenic reactions.

There are carcinogens, which means potential materials, but they may be in too low a concentration to do any harm.

Mr. SCHENCK. Thank you very much.

Mr. ROBERTS. Does the gentleman from Tennessee have any questions?

Mr. LOSER. I have no questions, Mr. Chairman.

Mr. ROBERTS. The gentleman from Pennsylvania?

Mr. BUSH. Mr. Heinen, up until the present time is there any device that has been developed that will control these unburned gases, which can be installed on motor vehicles?

Mr. HEINEN. There are a few that will reduce them somewhat, but when you speak of control, at, I presume the 80 percent plus level, no, there have been none to my knowledge, at any rate. There are some promising steps in that direction, and we are devoting a lot of time to the project. But I would have to say no, as much as I hate to do it.

Mr. BUSH. I know there has been a lot of study and a lot of thought, and the industry is very much interested in getting some device developed to take care of this situation which we all know exists and want to have corrected. We know it should be corrected and we want it corrected. It takes time to develop and find the gadget that will do it, however.

Mr. HEINEN. That is unfortunately true.

Mr. BUSH. Thank you.

Mr. ROBERTS. You state on page 5:

> In a broad way, this kind of instrumentation sufficed because it was generally known that the unburned portion of fuel supplied to the automobile engine was a very small percentage of the total.

Could you give the committee any idea of what this percentage of the total amounts to?

Mr. HEINEN. Yes. Something of the order of 5 percent, 5 to 7 percent. It varies an awfully lot in cars. There are some where you run a couple of percent, and there are some where you run up to 10 percent.

Mr. ROBERTS. When you are simply burning plain gas, is it different from what it is when you are burning higher grade, high octane?

Mr. HEINEN. The difference comes only if you get detonation. If you are below the detonation level, there is essentially no difference.

Mr. ROBERTS. Is there any difference in performance of a new engine and an old-type engine, or an engine which has been in use for many years?

Mr. HEINEN. I would prefer to answer the question an engine that is in a good state of adjustment and one that is not in a good state of adjustment. It is perfectly possible for a practically new engine to be in a poor state of adjustment. I would have to give you at the moment either an "I don't know" or a negative answer.

From what information we have at the present time we have been unable to relate milage or age against emission on anything that approximates a reasonable graph, this is something that is bothering us a good deal, and which has caused some rather elaborate studies, some of which ares till in progress, to try to explain this.

The first assumption would be that an older car would necessarily emit more because it would probable be in a poorer state of repair. This, however, has not come out from our studies of the cars that are being driven. As I say, we are investigating to find out why.

Mr. ROBERTS. Are you an engineer by training?

Mr. HEINEN. Yes, a chemical engineer.

Mr. ROBERTS. I am certainly not qualified to examine you, but I am frank to state we have had some testimony before the subcommittee which assigned a very much higher percentage to the presence of un-

burned hydrocarbons than you have assigned. As I say, I am not in a position to argue the question with you.

Mr. HEINEN. Just from memory, what do you recall it to be?

Mr. ROBERTS. I think we have had testimony to the effect that as high as 20 or 25 percent.

Mr. HEINEN. Under deceleration conditions, perhaps. That might account for it. A 25-percent emitter would just be such a horrible stinker that you couldn't live with the car.

Only under deceleration conditions, Mr. Roberts, I think if you will examine the testimony, you will find that that is the case.

Mr. ROBERTS. Of course, when you consider the price of gas today, and the fact that most of the new models require you to burn the higher octane gases, even your percentage represents a pretty good investment as far as the consuming public is concerned.

Mr. HEINEN. That is true.

Mr. ROBERTS. So there is an economic feature to this thing as well as health and other factors involved.

Could you be a little more specific about what the industry is doing in the way of developing control devices in this field?

Mr. HEINEN. Yes; I should be very happy to. In three companies we are currently testing either catalytic afterburners, or afterburners, or both. In five companies we have developed these deceleration devices that I discussed. Two companies, to my knowledge, have fundamental catalyst study work going on. Three companies, to my knowledge, have studies on the properties of combustion or basic combustion studies for application either to catalytic afterburner or an afterburner. There are considerable studies, and I cannot tell you exactly how many companies are doing this at the present time, but certainly at least three, studying maintenance factors with relation to their effect on this unburned or partially decomposed—I think we had best put it—gasoline. I have no doubt forgotten a lot of stuff here, but that will give you an idea of what we are doing in the area of devices. There is an awful lot of information that has to be obtained before you can operate on devices. This is the reason I wanted to present the slides.

I hope we have a chance to do so. We have had to develop instrumentation for this particular purpose. Indeed, the particular piece of instrumentation that you saw was developed specially for this investigation, Mr. Schenck, and it cost us something of the order of $100,000.

There has been a lot of other instrumentation developed in order to try to get a reasonable definition of at least the total emission and how it varies. As you will note from my testimony, I point out that that is completely insufficient for the purposes of this bill, because this bill requires not just a knowledge of the total amounts and how they vary, but it requires specific knowledge, which points out how each one of these literally thousands of materials change with maintenance conditions, change with base stock going in, change with operating conditions and so on.

We are working on that instrumentation, too, I might add, and we are working with the Bureau of Standards at the present time, through the coordinating research council, which I happen to head, on a gaschromatographic method development study at the rate of, I believe, $58,000 so far. This will give us a better definition, will give

us a chance to come closer to what you ask for, Representative Schenck. The technology is not there where we can do exactly what you want to know.

But we are closer than we were 4 years ago. This, I think, has to be included in the background of what are we doing about devices, because it is a necessary step.

Before you get to one point, you have to know what you have at another point to take care of.

I think that would be about my answer, without going into greater detail, unless you wish.

Mr. ROBERTS. Are there any further questions?

I have just received word from the House that the subcommittee will have permission to sit this afternoon.

I think we might take your slide presentation at this time, if you wish. That means we could hear all the witnesses.

Mr. HEINEN. Fine. I would like to introduce Mr. James Chandler, vice chairman of the committee, and who has prepared this presentation and will present it to you gentlemen.

Mr. SCHENCK. Before you leave the stand, it is my understanding that air is approximately 20 percent oxygen, and that the definition of burning is when something will unite with oxygen, and, therefore, only about 80 percent of the air is actually burnable after it is united or after it is mixed with some type of fuel.

Mr. HEINEN. That is right.

Mr. SCHENCK. And, therefore, your effort toward getting a perfect combustion is also limited within that field.

Mr. HEINEN. Yes. I might point out that the 80 percent has a nasty way of combining with the 20 percent to produce oxides of nitrogen, which is another irritating product of every type of combustion, including the exhaust.

Mr. CHANDLER. Mr. Chairman, and members of the subcommittee, I would like to indicate to you that this type of talk has been prepared and used throughout our industry, and particularly my own company, for presentations to our managements, because they are concerned with this problem, and we endeavor to keep them informed at all times. They, in fact, have asked for such information.

Mr. ROBERTS. If the gentleman will excuse me, the Chair would like to announce that word has just been received that the Navy successfully placed a satellite in orbit about 30 minutes ago. Being an old Navy man, I am glad to make that announcement.

Mr. HEINEN. I am afraid what I am going to say will be pale in significance. I am very pleased to hear about it, however. (Slide.)

Mr. CHANDLER. As you can see in this slide, this is a picture of what happens, both geographically and meteorologically, to produce smog in a specific area.

We have what is known as an inversion layer, or hot compressed air over the cooler air on the ground. Therefore, air does not rise.

We have mountains surrounding the city, and very, very light onshore winds, averaging 3 to 5 miles per hour throughout the year, whereas in most cities you approach maybe 10 or 15 miles per hour. (Slide.)

This shows a map of Los Angeles which shows the area surrounded, for the most part, by mountains. (Slide.)

The next few slides, as fast as they can be run through, merely show you pictures of smog. The main point we would like to make here is that these reactions occur in very good weather. In other words, it is the sunshine that actually contributes to the problem. (Slide.)

Mr. ROBERTS. May I break in for a moment?

I would like to say to members of the press they may take seats in front of the subcommittee.

Mr. CHANDLER. Here, again, we see the haze. I am sorry the screen is not large enough so that you can see in the background there is nothing to see because of the smog and the haze. (Slide.)

One of our engineers took this series on one of his surveys out there. This is a very beautiful day in Los Angeles.

It is very clear. You can see the mountains 40 and 60 miles distance. (Slide.)

Here you can see the brown haze above the houses, the smog in the background and the inversion layer. (Slide.)

Now the photographer is in the soup, again on a bright, beautiful day.

The next two slides show the same phenomenon. (Slide.)

Here we have the city hall on the right-hand corner of the screen, being taken from approximately the same location, and in the next slide city hall is no longer visible. (Slide.)

This is a very real problem.

There are four basic effects of the smog with which we are concerned. (Slide.)

This merely lists the effects of smog with which we are concerned—eye irritation, reduced visibility, crop damage, and we have listed here for our own purposes health damage, not because we know of any at this time, but we are aware that such things could happen sometime in the future. (Slide.)

This slide shows the basic hydrocarbon theory with which automobile exhaust is concerned with air pollution. That is hydrocarbons, or unburned gasoline react with the oxides of nitrogen in automobile exhaust in the presence of sunlight to form ozone or oxidents and these irritants of smog.

Here I want to emphasize that the offender is the reactant.

It is the result of the reactants. In other words, not the hydrocarbons by themselves or the sunlight by itself, but the result of the sunlight reacting with the unburned hydrocarbons and the oxides of nitrogen to produce these effects of eye irritation, crop damage, and reduced visibility. (Slide.)

This slide will give you an indication of the growth in the Los Angeles area, which, again, has pinpointed this problem. (Slide.)

I am sorry, this next slide is an indication of the emissions. The top group of figures there are from trash burning, and as the people from Los Angeles will point out to you they have eliminated incinerators, and, therefore, eliminated this particular source of pollutants.

The next one shows figures from industry and the bottom from automobile exhaust. (Slide.)

This slide shows some of the growth statistics for the area, which indicate for the most part that the population in Los Angeles County has doubled since 1940, and with this you have had a very tremendous

increase in automobile population and the consumption of gasoline. One of the statements earlier made was that they needed a new school every Monday morning in Los Angeles County because of the rate of growth.

In other words, it has been a fantastic rate. (Slide.)

This slide, I believe, shows this in curve form. Starting with 1930 to 1940, you can see the very modest rise in gasoline consumption, population, motor vehicles, and from 1940 on the curve is climbing much more rapidly, particularly estimated for 1960.

In fact, I think they have already exceeded the 1960 estimates. (Slide.)

Our industry, having become aware of this problem, and having visited Los Angeles, developed a program, an immediate program, to study the motor vehicle gases.

In other words, our earlier instrumentation that was available to us prior to this work, the Orstat analyzer was one of the best we had to measure carbon dioxide and monoxide in large percentages.

This process got us into parts per million. The instrumentation so fare developed only gives you gross hydrocarbons in terms of hydrocarbons per million.

Our industry also wanted to reduce the visible emissions, because they not only are not beneficial but they indicate poor motor maintenance and poor tuning.

We wanted to inform our own industry of this loss of gasoline that you pointed out and remarked upon of anywhere from zero to 15 or 10 percent in the exhaust.

We established immediately technical liaison with the many groups working in this particular area. To do this job, we had to organize. (Slide.)

Here is an organization chart of the Automobile Manufacturers Association, starting out with the board of directors, which is composed of the presidents of our various automobile companies. Reporting to them is an engineering advisory committee, which is composed of the vice presidents of engineering of the various automobile companies. They have created the committee of which Mr. Heinen is chairman and I am vice chairman, represented here today, the vehicle combustion products committee.

This committee had to organize, and it created eight special groups: An induction system panel, to work on the intake of the engine; an exhaust system panel to work on the afterburners; a data analysis panel to coordinate the results and all of the data flowing from the many groups and present them to us.

We ran a traffic survey panel in Los Angeles to define how the average driver operates his automobile. If we did not prove anything else, we certainly pointed out that there is nothing that exists that is a steady State operating condition.

This is very impressive when you understand some of the technology. We had a new devices panel composed of patent people so that anyone outside the industry would have ready access to us in a legal manner to get their ideas submitted to us and cleared so that we could examine them for the application to the problem.

We created a special group on exhaust smoke to help specifically in Detroit, available nationwide, to help law enforcement agencies,

the policemen, on how you define a smoking exhaust and how you rule whether it is offensive or in excess.

We have a special advisory committee on exhaust systems engineering to help us in regard to the placement of some of these afterburners and things in the car itself which is going to be quite a problem.

We have a special group on carbon monoxide, which developed procedures for evaluating monoxide conditions inside and outside the automobile. (Slide.)

We also went to the Coordinating Research Council for help in the very specific areas of analysis of exhaust gases. The Coordinating Research Council is sponsored by the automobile industry through the Society of Automotive Engineers and the Petroleum Institute. The two industries work on problems of mutual interest, for the most part fuel and lubricant problems in the engine and throughout the automobile.

This council created a group called the group on composition of exhaust gases, and Mr. Heinen is chairman.

There were four panels: A literature survey panel, which dug into all existing literature, and a sampling and analysis panel which worked in great detail to develop procedures which did not exist for sampling and analyzing exhaust gases in great detail. Then a variables panel to study fuel, lubricant, and engine variables on exhaust emissions to find out how things happen as things change; and a field survey panel.

The field survey panel conducted two surveys in Los Angeles to find out what the exhaust contained; in other words, of cars in the field.

We know more or less what is coming out as we build them, but what happens after they have been out in the field? What is the representative population of cars put out? (Slide.)

Now let's talk a little bit about instrumentation development. In the early stages we had none but those already existing, which were not particularly suited to the problem.

You are looking at a $40,000 mass spectrometer, which was helpful but was not the type of instrument that would give us information on what was going on during changing operations. (Slide.)

This shows a laboratory type of infrarad analyzer, about a $25,000 instrument. This took a grab sample of exhaust and analyzed it and gave us some indication of what was inside. (Slide.)

We obtained this from cars on what we call a chassis dynanometer, where we could load the rear wheels and take samples from underneath. (Slide.)

This gives you a concept of using an evacuated bulb and taking samples. As you can see, these methods are crude and somewhat limiting, because they represent an instantaneous grab sample and do not give us a representation of what is going on continuously in the automobile exhaust. I do not have slides at the moment, but as a result of a great deal of work an analyzer was developed which gives us—the one, I believe, that Mr. Schenck saw in Detroit—which gives a continuous record of the hydrocarbons coming out the tailpipe. (Slide.)

This slide shows a particular airflow meter which was developed by one of the laboratories for the field survey work.

We wanted to know instantaneous fuel flow. This is very difficult to measure on a mass-survey basis. With this rather novel airflow meter and by measuring CO and CO_2 we compute fuel flow. This was developed by the group and used extensively on field surveys. (Slide.)

This shows the indicating heads for this indicator. (Slide.)

This slide shows a chart of the result showing the changes. This, again, exemplifies the change in airflow through the engine; in other words, the exhaust gas in about the same quantity, starting out with idle on the extreme right and then the changes as the car accelerates, shifts, and steadies off at cruise, and then drops back down to the idle flow during deceleration. (Slide.)

This slide is what we call a schematic diagram of all of the instrumentation required in the field survey. It shows the hydrocarbon analyzers, the airflow meters.

It shows stop-starting at the top, the airflow meter at the top, all of this instrumentation, with the recorders and power supplies, and what have you, more of it in the trunk, and it also shows where we took the samples for determining oxides of nitrogen in the field survey. (Slide.)

This picture from the first survey shows some of the instrumentation in the car. In all of these in the first survey we had to have a man riding in the trunk during the testing.

In the second survey we were able to keep everyone in the passenger compartment. (Slide.)

This shows, again, some of the instrumentation inside the car. These were taken by engineers during the actual survey. (Slide.)

Another instrument developed was an integrator which combined the airflow signal and hydrocarbon signal to give us an instantaneous record of the amount of hydrocarbons being issued. We have used this in Detroit to evaluate some of the deceleration devices developed in order to determine what their overall effectiveness would be. (Slide.)

This slide probably is one of the most basic studies or definitions of our particular problem in regard to hydrocarbons, because it shows hydrocarbon emission expressed as the weight of the supplied fuel to the carburetor, versus intake manifold vacuum. At the extreme left, the engine is doing all the work it can. It is wide open throttle. The accelerator is on the floor. The rate in terms of concentration of emission is extremely low. As you can see, it is about 2 percent. On the percentages, this is the rate of percentage. As we come to the right, through the crucial condition, we approach at about 19 to 20 inches of manifold vacuum the idle of the car, and then we show, as we go beyond idle, a very abrupt rise.

This is the deceleration, this is when the car is going down the hill, and you have your foot off the throttle. It is a very steep and abrupt rise in hydrocarbon emission. It was this basic type of information, along with some early work that we obtained from some of the California laboratories, which indicated that the deceleration area was a good place to start working on this problem, because the early data indicated that over 60 percent of the total emission of hydrocarbons to the atmosphere came during the deceleration.

We will see later that we don't believe this to be true. We think it is in the order of about half that now, as we have gotten better information, and better instrumentation.

However, to proceed here, in defining the problem, again, this slide shows the effects of air-fuel ratio during idle. (Slide.)

This shows that as you approach the optimum air-fuel ratio for engine operation, we also give out the least amount of unburned fuel. This does show the problems that happen when you get the car tuning.

When people start fiddling with their carburetors, they go rich and we have more emission.

Also, as cars age this is one area which will tend to rich. Almost anything out of adjustment will tend to make it rich, because if it is too lean it will not run. (Slide.)

This shows the effect from early data of the transmission on hydrocarbon emission, and indicates that we have already helped ourselves somewhat by going to the automatic transmission in most cars because of the fact that we do not have a fixed coupling between the engine and rear wheels. It allows the engine to slow down sooner, and therefore, results in less emission of hydrocarbons to th atmosphere.

We spent a lot of time talking about instrumentation. We are very concerned about defining the problem. (Slide.)

This is one of the first steps, so to speak. To do that, we had to know not only what was in the exhaust but how people drove. We ran a traffic survey. Here, again, we define how people drive in terms of manifold vacuum or throttle opening, going, if you will, from the extereme left of wide open throttle for rapid acceleration to a moderate acceleration, to cruising, say 12 to 19 inches of vacuum; then to idle and beyond idle we go into mild or rapid decelerations. We define what the car is doing both in terms of the cars' speed and also in terms of manifold vacuum.

To record and measure these various portions of driving, we developed some instrumentation, these traffic counters. (Slide.)

Here, again, is a schematic, showing the relationship of these gages and valves and what have you. (Slide.)

In this next slide is shown a picture of the instrumentation, of the counters themselves, and some of the valving. (Slide.)

This shows a picture of how this fits right under the dashboard. We went to Los Angeles with 3 or 4 sets of this instrumentation, and with very good help, in fact, most of the manpower being supplied by the air pollution control district, we ran many, many tests of different kinds of cars, and drove them in heavy traffic, in mild traffic, over a route which they had established as being representative of most of the driving in that area. (Slide.)

The next few slides show some of the results of this survey. It shows the effect of driver variation.

Here are four different drivers who have a widely varying percentage of their time in the various categories, acceleration, road load, idle, deceleration, and so on. No matter how fast the man drives, this shows it takes him just about the same amount of time to get there.

The average speed varied from 25.1 to 26.6 for this particular route. And yet we have everything from the very cautious driver to the jack rabbit, being represented by the way the man drives.

This is pretty indicative of why it doesn't pay to drive in a pretty reckless manner. (Slide.)

This show the effect of transmission mainly on rapid deceleration. With a manual transmission you have much more of the high manifold vacuum than with the automatic transmission. (Slide.)

This slide shows the effect of the freeway versus the business routes, showing the load for the freeway as 56 percent of the time. In other words, the expressways which allow cars to go along at maintaining a good speed and maintaining a constant speed are very helpful in reducing emission. (Slide.)

This slide shows the effect of different types of highways. This is, again, some more complex instrumentation, some of this provided by General Motors Proving Grounds, showing that on a freeway a man averaged 48 miles per hour and in the business routes he only averaged 13 miles per hour.

This, again, gives significant data in calculating total emission. (Slide.)

This shows the effect of different types of roads on fuel economy, ranging in this particular instance from an average of over 16 miles per gallon for freeway to 10 miles per gallon for the business routes.

All of this information tends to show that the steps Los Angeles, particularly, is taking, and all major cities are going to in terms of freeways, are going to be very beneficial in helping with the problem of exhaust emission. (Slide.)

As a result of all of this survey work, we came up with a recommended driving cycle, which actually we think is the average driving cycle for the average Los Angeles driver. There is no such person, obviously, but this puts them all together, showing that the average man idles 15 percent of time, cruises 16 percent of the time, accelerates 36 percent of the time, and decelerates 32 percent of the time, in other words, he is only cruising 16 percent of the time in a steady state cruising condition. Most of the time it is up and down. He is moving ahead a little faster or slowing down.

This is the way people normally drive, which adds to the complexity of our particular problem. (Slide.)

This slide here shows a tape of which there were something like 2 miles of tape coming from the field survey, in which over 300 cars were tested in the Los Angeles riverbed. All of the information on this tape, airflow, two different measures of hydrocarbon emissions, carbon monoxide, all of these data were taken to try to find out what the cars in that area were putting out in their tailpipes. It took over 600 man-hours to prepare the tapes for the IBM machine, and we had over 220,000 IBM cards of data to come out with what I'm going to show here in 2 slides. (Slide.)

These presentations go very rapidly and you don't have any concept of the amount of work. In fact, it took a year just to get these data together to come up with these results.

We show here oxides of nitrogen, which is one of the offenders in creating smog, being very low during idle and deceleration, and being at a reasonable rate during cruise and acceleration.

This results in roughly 400 tons per day calculated emission in the Los Angeles area. (Slide.)

This slide shows a compilation of all hydrocarbon results. Here, in terms of weight percent unburned, which is the middle column, we

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go from 6.5 percent to 4.9, to 4.6, and as high as 14 percent of the gasoline through the tailpipe as a compilation of the entire survery. (Slide.)

This particular chart is very significant because it is an attempt to show by comparing or cross-calculating the results of the traffic survey with the results of the field survey to show when the hydrocarbons are coming out of the tailpipe. They show that very little, in orange there is coming out during idle, because we have very low airflow through the carburetor.

It shows that in acceleration you are actually producing the most, not because the concentration is high, because it isn't, it is very low, but the airflow is high.

It takes power to move the car.

Mr. SCHENCK. Is that also because of the pumps on the carburetor?

Mr. CHANDLER. Not particularly, sir, because the concentration is still low. The pump goes through there to keep things cool and keep a smooth operation, but the combustion is pretty good.

Mr. SCHENCK. I mean to pump additional gasoline in.

Mr. CHANDLER. That is right, but the additional gasoline is pretty well consumed during wide-open throttle, because you have more air going through. It is a shade higher, but the main reason being that you merely are opening the throttle and pulling a lot more air through the engine.

The concentration does not rise that much as you might expect from the originating shot of the accelerator power.

Cruise is a lot lower than one might expect because you are only doing it 16 percent of the time and because the airflow is relatively low. It doesn't take too much to keep the car going along. And deceleration is relatively low mainly because the airflow is low during deceleration. Your throttle is closed. Whereas the percentage might be relatively high, the total actual emission is very low, and approximates approximately 30 percent of the emission. We have gone to some length to show this, because, as I said, the earlier information indicated that over 60 percent of the hydrocarbons came out during the deceleration.

When we started out on this problem, we didn't do things in the logical sequence. We didn't define the problem, develop the instrumentation, do all of this measurement, find out where most of the hydrocarbons were coming out, and then start the development of devices. This is the way we would have preferred it. That is the cheapest way, it makes the most sense, and technically it is the most sound.

But the pressure is great, and we are indicating that we responded to this pressure by starting work on devices at the same time we started defining the problem and developing the instrumentation.

So we started to work on the assumption that over 60 percent came out during deceleration. We thought this was wonderful.

We will try to cut down fuel flow during deceleration and solve the problem. These data seemed to indicate that if only 30 percent was coming out during deceleration, the potential for overall reduction becomes very much smaller.

The next few slides will show what we have done parallelling all of this other work on the deceleration devices. (Slide.)

We started out by defining the methods for reducing emission. You could have manifold vacuum controls or fuel controls, and in the exhaust system have catalytic or afterburners. (Slide.)

We wanted 70 percent reduction in total emission for a basic type of deceleration, and then there would be devices required for both new and old cars. They had to be low cost, easily installed, easily maintained. The device, and this is very important, must not introduce undesirable effects, either from the driver's point of view, or in the actual exhaust emissions. (Slide.)

This slide shows a long list of types of devices and for each of these types several were submitted. I think we screened well over 30 devices individually and tested most of them as we tried to pin down the type which would be the most effective. (Slide.)

This slide lists some of the major problems in these various types of devices. In the fuel cutoff, the main problem was to keep the engine running after deceleration. You cut the fuel off and when the engine wants to idle, there is no fuel there and it would stall. This is a dangerous situation for a driver.

In the vacuum controls, there was a loss of engine braking, among other problems, and this has been one of the major criticisms of this type of device. The first type of device we tried was the idle fuel cutoff, which would stop fuel flowing during deceleration. (Slide.)

This merely shows the normal operation. (Slide.)

This shows what happens when the little piston goes up and admits air into the system and fuel is not made to flow during deceleration. It is tricky to operate without loss of engine.

This looked good from earlier studies, but our traffic studies pointed out that people do not decelerate from 50 to 20 miles without braking. The average is from about 30 to 15 miles with braking. We found out this device became very ineffective during the types of deceleration we learned actually existed in Los Angeles. (Slide.)

This shows one of these devices installed on a carburetor. All of the companies went to a great deal of work in putting these on their production carburetors and trying to make them work effectively. (Slide.)

This shows the results of a typical deceleration. The red portion shows a typical deceleration in terms of emission without a device, and the green area shows the emission with the device. Therefore, the difference is shown between the two.

This resulted in about a 40-percent reduction for a 30 to 15 mile deceleration, which we did not think really was very large. (Slide.)

Here is a schematic of what we call a slow leak dash throttle, something to keep the throttle from closing abruptly and, therefore, keeping the manifold vacuum down. This device was very simple but was very difficult from a driver's point of view, because the engine tended to race and required excessive braking. (Slide.)

A refinement of this was the vacuum limiter, which controlled the engine manifold vacuum to a set point; we just picked 22 inches of manifold vacuum as being the point beyond which we did not want to go in vacuum because of the high emissions, and below which there would be no loss of engine braking.

This introduced some undesirable characteristics, so we had to put safety gadgets on it. (Slide.)

This shows schematically how we wanted switches so it would operate only during the drive position, and during heavy braking or crash stops the device would be inoperative, it automatically became somewhat complex in order to do the job properly. (Slide.)

Here it is installed on an engine down to the right, below the carburetor. It is very simple. It was external to the engine which made it much simpler than the idle cutoff because it did not interfere with the operation.

The results were pretty good. (Slide.)

Here, again, the difference between the two curves is a little greater than you saw in the other one. Here we are up to about a 60 percent reduction in overall emission. (Slide.)

This shows a comparison of results from all types of devices versus various types of deceleration. Let it be said that the top curve, where it says "throttle opener," there is this vacuum limiter device, and it approximated about 55 percent overall effectiveness, which is the best the device would do.

Early in 1957 the industry representatives visited the Los Angeles people and submitted these devices to them. They were the best we could do, mainly because the problem was not as we had thought it was when we started out.

Using the integrator instrumentation, it became apparent that the best any type of an induction system device could do, anything we could do with a carburetor, was about a 25 percent overall reduction in hydrocarbon emission.

So we have submitted these devices in 1957. We have pointed out the problems and the rather low productivity from them, for reasons obviously far beyond our control, and the district is in the process of evaluating them to see if they wish to have them installed. We are fairly sure they don't want them because they don't do a good enough job and will cost the motorist money.

They will impose inspection problems and maintenance problems, and are not what we think would be a good ultimate system. These are devices that could have been made available in production this year, had they been requested, in answer to Mr. Kennedy's statements earlier today. (Slide.)

In terms of the exhaust-system device, this picture is probably as good as many to illustrate the complexity of this particular problem, because it shows representative catalytic afterburners installed on a car.

These are big compared to the man standing underneath the car. They are bulky in their present form. It is hoped that they can be reduced in size and increased in effectiveness.

But this particular one still is not what we would call commercial, either in its operation or in its application to vehicles. However, it does represent a type of catalytic afterburner which has shown very good immunity to lead poisoning, which has been one of the outstanding problems in terms of catalysts.

You have people here today who can tell you much more than I about the catalyst. The catalyst we think is probably the final answer to the exhaust-system problem if we can find a catalyst which is immune to lead poisoning, and which will have the degree of effectiveness in removing hydrocarbons from the exhaust. It is in this particular area that most of our efforts are now concentrated. (Slide.)

This shows a schematic of an early-type flame-type afterburner in which no catalyst is employed. The main problem here is that there is insufficient fuel in the exhaust to burn without help during cruising and acceleration.

You can maintain a flame during deceleration and idle, but during a cruise condition or acceleration when most of the hydrocarbons are coming through, they are actually in such low concentration that it is impossible to maintain a flame for any type of effectiveness. (Slide.)

This shows an early type catalytic afterburner on the left compared with a standard type muffler. This was taken several years ago. It shows not only is the catalytic afterburner in this instance very large, but, unfortunately, the mufflers have shrunk since that time, to make the comparison a little worse as far as installing these in automobiles. (Slide.)

There has been a considerable amount of work done in the industry in terms of basic catalyst research. The next few slides represent some of the data.

This shows a schematic of a single-cylinder engine test where at the bottom four different kinds of catalysts could be evaluated at the same time. (Slide.)

Here is a picture of this test apparatus, with the engine buried behind the coils there, and the catalyst chambers being in white right in front. This engine was operated during simulated cruise, idle, and deceleration conditions to determine mostly the effectiveness of these catalysts in removing hydrocarbons and their immunity to lead poisoning. (Slide.)

This slide lists out of 100 catalysts screened in the laboratory with a laboratory test procedure, and they even had been selected, out of that we have here about 8 catalysts which showed enough promise on laboratory bench tests to be worthy of the single cylinder engine test program. (Slide.)

I will not go into detail with this slide, but it shows basically percent hydrocarbon conversion versus engine test hours for various types of catalysts, showing in this case that most of these fell off at 100 hours. Incidentally, these slides are all with unleaded fuel. (Slide.)

Here we see the grand daddy of them all, platinum, which, with nonleaded fuel, is practically 100 percent effective across the board. They are available if you happen to burn unleaded fuel. (Slide.)

This shows three more types of catalysts, one of which is vanadium oxide, and which maintained a reasonable effectiveness, about 80 percent, throughout this test cycle on unleaded fuel. The next step was to put lead in the fuel. This shows first of all what happens to platinum. When you put lead in the fuel, you get to 100 hours and it has no effectiveness at all. (Slide.)

This shows the effect of lead on the others, and there, again, most of the catalysts decline because they become poisoned by the lead in the gasoline. (Slide.)

This shows that this particular vanadium catalyst was falling off, but it still maintained reasonable effectiveness and showed some potential. It is this particular catalyst that is now undergoing full-scale engine tests, both on the dynamometer and on the road. It has a long way to go before it will be perfected if it ever will be, but to date from our industry point of view, this does appear to have some pretty good potential. (Slide.)

The last slide here gives an outline of our industry program for 1958.

I have given you, very, very rapidly, a summation of some 5 years of effort. In 1958 we anticipate very little work on induction-system devices, pending any kind of an answer from Los Angeles.

We sort of have, I think, a mutual agreement that we probably will not do much in that area, although we are certainly willing to if they so desire.

Eighty or ninety percent of our effort will be in exhaust system devices, a continued effort to develop the catalyst to the point where it is a feasible commercial application with leaded fuel. I wish I could predict when this will be done. It is simply an impossibility, because we have not gone even to the point of production engineering.

We are still at the point of developmental engineering. We are still trying to discover the right combination. When you apply basic research to solving an immediate problem, I am sure you recognize this will require a lot of time. We will be doing a lot of work on instrumentation and analytical techniques, because we want to know not only the gross emissions, but also the particular hydrocarbons coming out in regard to, among other things, health considerations.

We want to study more in terms of engine variables, to find out more about the effects of operating automobiles, and what it does to exhaust gas.

We will be doing more with exhaust systems engineering, so that we will be able to apply these burners to automobiles. We are studying a medical program to evaluate the effects of auto exhaust on health, and we are continuing what is for us a basic work and continuing work of basic research on combustion, and some basic research in one laboratory on atmospheric reactions.

Mr. ROBERTS. The Chair would like to thank the gentleman for this very thorough presentation. I realize the witness was rushed to make the presentation, but I would like to say that I think you have done a very splendid job.

The subcommittee is very grateful to you.

Are there any questions from members of the subcommittee?

Mr. BUSH. I wish to concur in what you said.

You have furnished a lot of valuable information, and it shows that you are endeavoring to bring about a solution with some kind of device that will solve this problem.

Mr. CHANDLER. These are all technical papers, in great quantity. We have published a great deal. In fact, we have published just about everything we know. But these are all technical papers resulting from all of this work which we have made available in various symposiums and whatnot.

Mr. ROBERTS. I would like to say that I doubt seriously, because of the volume of that material, that it can be made part of the record. It can be filed for reference by the subcommittee. The slide presentation, if you have that in form so that plates can be made of it and it can be made available to the subcommittee as reference material also.

Mr. CHANDLER. We have no text as such, other than what was recorded, but we will make the pictures available.

Mr. ROBERTS. I appreciate that very much.

The subcommittee will stand in recess until 2 o'clock this afternoon.

(Whereupon, at 12:40 the hearing was recessed, to reconvene at 2 p. m. of the same day.)

AFTERNOON SESSION

The committee reconvened at 2 p. m., upon the expiration of the recess.

Mr. LOSER. Is Dr. Clarence A. Mills here?

Dr. MILLS. Yes.

Mr. LOSER. Dr. Mills comes from the University of Cincinnati at Cincinnati, Ohio.

We are very glad to have you here, Doctor, and to have your views on this bill and on any other matters that you care to speak on.

STATEMENT OF CLARENCE A. MILLS, M. D., PH. D., PROFESSOR OF EXPERIMENTAL MEDICINE, UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

Dr. MILLS. Thank you, sir.

Gentlemen of the committee, I have a prepared statement copies of which I have given to the clerk for distribution.

I would like to read just a few sentences from that prepared statement, first.

Being well aware of the many frustrating delays in the progress of air-pollution relief and well aware also of the personal uncertainties of life's long-term continuance, I have tried to keep in printed published form my findings and conclusions with respect to the air-pollution problem.

I, therefore, offer for incorporation into my statement before your committee, the following three of my published articles:

Exhibit A consists of a guest editorial entitled "No Smogs Threaten Community Health," published in the official organ of the county medical society, the Cincinnati Journal of Medicine, in 1957.

Exhibit B consisting of a detailed presentation of my findings in the Los Angeles smog situation in a study carried out as a consultant to two different California State legislative committees. This is entitled "Respiratory and Cardiac Deaths in Los Angeles Smogs." which was published, the last presentation of it, in the American Journal of Medical Science in 1957.

Exhibit C consists of a detailed report of the extensive study we carried out in the Cincinnati area on cancer, entitled "Tobacco Smoking, Motor Exhaust Fumes and General Air Pollution in Relation to Lung Cancer Incidence," published in 1957 in Cancer Research.

Mr. LOSER. Doctor, do you have those exhibits?

Dr. MILLS. Yes.

Mr. LOSER. Without objection they will be incorporated into the record.

(The material referred to follows:)

DO SMOGS THREATEN COMMUNITY HEALTH?

C. A. MILLS, M.D.

■

Reprinted from the Cincinnati Journal of Medicine,
38:259-261, 1957

EDITORIALS

DO SMOGS THREATEN COMMUNITY HEALTH?

In the year 1939, St. Louis began the urban movement toward relief from the smoke palls then enshrouding the world's industrial cities. Increasingly dense pollution clouds blanketed cities as coal-fired heat and power plants kept pace with the growth of the industrial centers. Within a single decade after 1939, most American cities experienced amazing relief from this black coal-smoke overcast—only to leave exposed, however, the grayish fly-ash and small-particle or poison-gas smogs formerly masked by the carbon soot. These small-particle smogs are today undergoing a further insidious change, as the increasing outpouring of motor exhaust gases is converting them over to the irritating ozone-type smogs which have so plagued Los Angeles in recent years. Coal smoke has given way to ozone smog as we have shifted from solid to liquid fuels and to such very widespread use of liquid-fuel motor transport.

Leigh White's recent article in the *Saturday Evening Post*, "The Creeping Menace Called Smog" (May 4, 1957), highlighted very well this shifting emphasis in the air pollution problem facing American cities. Whether or not these ozone smogs menace community health is one of today's high-ranking medical problems. The nation's industrial community has tried diligently to avoid blame in the situation by "playing down" all suggestions of any associated community health hazard, and in this they have had the support of their associated industrial hygiene physicians and engineers. Unfortunately the U. S. Public Health Service and several state health departments have seemed to take a similar stand, except when seeking long-term expansion funds.

Decision as to whether present-day ozone smogs do indeed constitute a health menace worthy of community action must arise from the more public-spirited segments of the medical profession. It is noteworthy, in this connection, that the Los Angeles County Medical Society has gone on record time after time in giving it as their earnest opinion that ozone smogs do indeed constitute a community health hazard calling urgently for remedial action. Similarly, back in 1939, the St. Louis physicians labelled their black smoke pall a health menace and thus provided the "must" basis for urgent remedial action.

Today we can go beyond the medical "opinion" stage, for a considerable body of scientific and medical evidence has accumulated through recent years of growing interest in smog health hazards. It is well that this evidence now be catalogued and made available as a basis for an enlightened medical judgment everywhere.

The term "smog" has come to mean an atmospheric haze of varying density in which minute water droplets (usually sub-micronic in size) have coalesced around so-called "condensation nuclei" in a polluted atmosphere, and onto or into these sub-micronic water particles have been absorbed or dissolved the various polluting particles or gases.

Nighttime "temperature inversions," so common in windless periods of clear weather, provide optimal conditions for smog formation.

Particle size is important to those breathing smoggy air, for particles larger than ten microns in diameter lodge mainly in the upper air passages, those from five down to two microns diameter mainly in the larger bronchial passages, those from two down to one micron in diameter in the finer

bronchial passages, while those of sub-micronic size penetrate deeply into the air sacs themselves and are deposited mainly on the walls of the air sacs and in the adjacent bronchioles. Gaseous pollutants also penetrate well into the air sacs but their absorption and retention is sharply less than when they are present in some particulate phase.

Whether the pollutants be SO_2, SO_3, H_2SO_4, mist, nitrogen oxides, organic aldehydes, ozone or any other of the many respiratory tract irritants, their acute damaging action consists of irritation, oedema and fluid outpouring which blocks the finer air passages, reduces vital capacity and produces death by aspyhxiation. These have been the findings in such acute smog episodes as that of 1930 in the Meuse valley of Belgium and at Donora, Pennsylvania, in 1948, involving human populations. Experimental animals and two voluntary human beings have provided further verification of the acute damage in previously well subjects. There is, in addition, the eye irritation which is troublesome but of little over-all significance.

Little is known of the more chronic forms of smog damage, except that there is a clearly significant association of Los Angeles smog density with the daily numbers of respiratory and cardiac deaths,[1] that severe smog episodes in Greater London show a similar relationship,[2] and that human lung cancer frequency in Cincinnati has been found associated to a clearly significant degree with exposure both to motor exhaust fumes and to general urban air pollution.[3] Kotin[4] is reported to have produced lung cancer in mice by having them breathe Los Angeles-type smog for forty weeks. There is a strong suspicion that chronic bronchitis and chronic emphysema are similarly related to the breathing of polluted air but definite epidemiologic proof is difficult to obtain because of variations in diagnostic criteria and because the diseases are infrequently listed as causes of death.

As would be expected, smog damage manifests itself in the air passages and lungs, accentuating cardiac failure and death only secondarily through inadequacy of the pulmonary circulation and blood oxygenation. Foulger[5] expressed the matter very clearly at the First National Air Pollution Symposium held in Pasadena in 1949: "We are concerned here with assessment of the health hazard which may exist more or less continually in large industrial areas such as Los Angeles or Chicago. . . . The fortunate rarity of acute incidents such as those in the Meuse Valley and at Donora must not delude us into thinking they are in a class apart. Actually, from the physiological point of view, they are mere magnifications of a frequent pattern. . . . The true test of health hazard to the general public from any particular atmosphere is the ability of this atmosphere, when inhaled, to produce physiological deterioration in exposed persons, and especially in those having respiratory or cardiac disease. No degree of 'cleaning up' of our cities can be considered satisfactory from the medical point of view unless it results in an atmosphere the breathing of which imposes no physiologic load upon the least resistant inhabitant, the sufferer from respiratory or cardiovascular disease. . . ."

Much work yet remains to be done in the establishment of maximal allowable limits of pollutants for community safety. The Meuse and Donora smog episodes were concerned with fatal concentrations of sulfur gases and sulfuric acid mist building up in the stagnant inversion fog of the confined valley areas. London's troubles also seemed related mainly to coal smoke and combustion sulfur gases. The sulfur gases from fuel combustion still present a definite part of the air pollution problem in American cities, but their importance is being rapidly overshadowed by the ozone or oxidant type of smog now known to depend mainly upon incomplete liquid-fuel combustion.[6] Sunlight, nitrogen oxides and unburned hydrocarbons from liquid-fuel motors, and inversion-type weather stagnation—these are the ingredients going into the formation of ozone smogs in American urban atmospheric mixing bowls. The degree of toxicity residing in such ozone smogs therefore now overshadow most other air-pollution considerations from the standpoint of community safety.

Ozone, formerly considered a much-desired health-promoting air constituent, is now recognized as one of the very toxic poison gases. Its maximal allowable concentration for an eight-hour exposure of in-plant industrial workers was recently dropped from 1 ppm down to 0.1 ppm[7] and this 0.1 ppm limit has been confirmed as not unreasonable by several workers in the field of industrial health.[8] This it at the detectable threshold of those with a keen sense of smell, so any smellable ozone seems to be too much for general safety. Damage to succulent plants begains at 0.1 ppm, and is marked at 0.2 ppm.[9] Bacteria and molds are killed at 0.2 ppm, and guinea pig death rates rise after months of exposure at this level.[10]

Daily oxidant or ozone maxima above 0.2 ppm in Los Angeles are associated to a signifi-

cant degree with elevations in the numbers of respiratory and cardiac deaths, the excess of such smog-associated deaths being 334 for the year 1954.[1] The San Francisco Bay Area is beginning to exhibit this smog-death relationship, although daily smog data available are as yet inadequate for establishing the mathematical significance of such association. Other cities are beginning to have ozone smogs (as at Cincinnati on October 15, 1956, and several succeeding days), but in none of them are daily ozone measurements available over a sufficient period of time for establishing the presence or absence of a significant relationship to respiratory and cardiac deaths.

Since community exposure to ozone smogs is limited to the daytime sunshine period—seldom beginning before 9 a.m. or lasting longer than eight hours in any given day—and since the respiratory effects of a single exposure are related to concentrations × time, it would seem logical to assess human and animal toxicity tests on this eight-hour exposure basis. Griswold of Los Angeles underwent an exposure of two hours at an ozone concentration of 2 ppm (the eight-hour exposure equivalent being 0.5 ppm), with severe irritational effects lasting two weeks and seventeen percent reduction in pulmonary capacity.[11] Clamann at the Armour Foundation in Chicago submitted to an exposure of 2.5 hours at 1.2 ppm (equivalent to eight hours at about 0.4 ppm), resulting in only moderate irritation and coughing; the next day 3.55 ppm for 64 minutes (equivalent to slightly under 0.5 ppm for eight hours), produced chest pain, shortness of breath, coughing, and a forty percent reduction in vital capacity (Associated Press report, June 23, 1956). Stokinger et al[12] found 1 ppm for six hours (equivalent to 0.7 ppm for eight hours) to kill fifty percent of exposed healthy young white rats mildly exercised for fifteen minutes out of each hour.

The case against ozone smogs thus seems sufficiently complete to warrant preventive community action. It would seem to be an obligation of the medical profession to point out this hazard to community health and to insist that all possible remedial measures be encouraged. Liquid-fuel motor exhaust fumes are today recognized as the largest single-type pollution component of urban atmospheres in America, outranking even the sulfur gases except in those areas still using coal as the major fuel. The maximum allowable concentration of ozone for urban atmospheres should be considered as 0.1 ppm (a barely detectable level for those with a keen sense of smell). Restriction of atmospheric ozone formation within any such maximum level will necessitate sharp curtailment of unburned hydrocarbon output in liquid-fuel motor exhausts.

Whether such exhaust gas curtailment will be attained by the use of afterburner mufflers, by fuel cut-off devices, or by other effective engineering methods is not yet clear. It is clear, however, that the development of effective devices will be greatly stimulated if polluted urban communities express in legal terms their determination to use such devices as they become available, creating thus a "compulsive" market. Such is the proposed ordinance now under consideration by the Cincinnati City Council.

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EXHIBIT B

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RESPIRATORY AND CARDIAC DEATHS IN LOS ANGELES SMOGS

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THERE is developing today a new type of community health hazard associated directly with the irritating ozone (or oxidant) smogs shown by Haagen-Smit[4] to arise largely from the action of sunlight upon atmospheric mixtures of the unburned hydrocarbons and nitrogen oxides derived from liquid-fuel motor exhausts. This ozone-type smog appeared first in Los Angeles over a decade ago, but it is now beginning to afflict other American urban communities also. It, therefore, becomes important that the community health hazards associated with it be evaluated as closely as possible and that necessary remedial steps be taken. It is closely associated with windless periods of temperature inversion when polluting materials are held trapped in the ground layers of a cloudless atmosphere and subjected to direct sunlight.

It is obvious that maximal allowable pollution of community atmospheres should be kept below the exposed population's sickness and death threshold. Such threshold limits for many pollutants have been carefully worked out for industrial in-plant workers; workmen's compensation laws have made this almost mandatory by holding management liable for any such worker health damage. Such limits have never been determined for outside community populations, however, nor can the limits established for 8-hour daily in-plant exposure of healthy workers be transposed safely to the 24-hour day-after-day exposure of community residents. Discussion of this point at one symposium[9] brought out hints that the in-plant limits are probably 4 to 20 times higher than those to be considered safe for continuous community exposure. This is especially true where the polluting materials possess irritating effects upon the air passages which lead to progressive and accumulative damage.

In order to be doubly certain that Los Angeles-type smogs carry a significant hazard to community life, we have given careful reappraisal to the 1947–1949 Los Angeles data discussed briefly in a former publication[5]. Also these older findings have been strongly reinforced and broadened by the addition of data from more recent years (1953–1955). It now seems clear that residents of the Los Angeles area are facing very considerable and serious respiratory hazards in breathing their smoggy air at its present levels of pollution. These hazards seem to arise mainly from the presence within their atmospheric "mixing bowl" of ozone or total oxidant concentrations now recognized as dangerously irritative to plants and to the human air passages.

Table 1 presents a general month-by-month summary of the 1947–1949 data on day-by-day respiratory and cardiac deaths in Los Angeles as related to the Stanford Research Institute's smog index[7]. The data on deaths were supplied by the California State Department of Health and the smog index information was supplied by the Stanford Research Institute in the form of a continuous graph.

In order that the 1947–1949 death

data of Table 1 might be subjected to unified correlation with the smog index, such correction was applied to all daily death numbers in each month as would bring that month's average for its nonsmoggy days to 42. Such correction to uniform base for the whole 3-year period erases seasonal and temporal changes unrelated to smog episodes while leaving undisturbed all incidental day-to-day variations and those associated with smoggy periods.

Preliminary examination of the corrected death data indicated insignificant changes in daily numbers of deaths so long as the smog index did not rise above 5, hence we classified as nonsmoggy all days with an index of 5

TABLE 1.—RESPIRATORY AND CARDIAC DEATHS IN LOS ANGELES SMOGS.

Year and Month	*Nonsmoggy (SRI Index, 0–5)*		*Moderately Smoggy (SRI Index, 6–9)*			*Severely Smoggy (SRI Index, 10 or Over)*		
1947	*No. of Days*	*Daily Deaths*	*No. of Days*	*Daily Deaths*	*Total Excess*	*No. of Days*	*Daily Deaths*	*Total Excess*
Jan.	29	52.5	0	0	0	2	50.5	− 4.0
Feb.	26	49.5	1	58.0	+ 8.5	1	44.0	− 5.5
Mar.	31	43.7	0	0	0	0	0	0
Apr.	29	41.6	0	0	0	1	63.0	+21.4
May	29	40.0	0	0	0	2	47.0	+14.0
June	30	36.8	0	0	0	0	0	0
July	26	38.3	1	34.0	− 4.3	4	42.8	+18.0
Aug.	31	38.6	0	0	0	0	0	−0
Sept.	22	38.6	5	35.4	−16.0	3	40.7	+ 6.3
Oct.	29	38.6	0	0	0	2	35.0	− 7.2
Nov.	28	44.2	1	58.0	+13.8	1	58.0	+13.8
Dec.	31	52.7	0	0	0	0	0	0
Year	341		8		+ 2.0	16		+73.5
1948								
Jan.	29	61.5	1	82.0	+20.5	1	80.0	+18.5
Feb.	29	50.5	0	0	0	0	0	0
Mar.	31	47.5	0	0	0	0	0	0
Apr.	30	44.0	0	0	0	0	0	0
May	30	40.0	1	48.1	+ 8.0	0	0	0
June	30	39.2	0	0	0	0	0	0
July	26	37.2	5	34.2	−15.0	0	0	0
Aug.	24	37.1	5	36.0	− 5.5	2	41.0	+ 7.8
Sept.	15	34.3	4	39.0	+18.8	11	39.1	+52.8
Oct.	23	37.8	6	35.2	−15.6	2	43.0	+10.4
Nov.	26	42.0	3	35.7	−18.9	1	42.0	0
Dec.	31	50.4	0	0	0	0	0	0
Year	324		25		+ 2.3	17		+89.5
1949								
Jan.	31	54.7	0	0	0	0	0	0
Feb.	25	54.4	3	57.3	+ 8.7	0	0	0
Mar.	30	51.0	1	68.0	+17.0	0	0	0
Apr.	20	45.6	9	46.9	+11.7	1	53.0	+ 7.4
May	29	43.0	1	52.0	+ 9.0	1	52.0	+ 9.0
June	27	42.7	3	45.7	+ 9.0	0	0	0
July	28	42.1	2	44.5	+ 4.8	1	40.0	− 2.1
Aug.	16	42.7	13	43.8	+14.3	2	39.5	− 6.6
Sept.	14	40.8	7	44.3	+24.5	9	49.0	+73.8
Oct.	22	44.3	5	46.2	+ 9.5	4	53.5	+36.8
Nov.	17	45.7	5	45.8	+ 0.5	8	45.1	− 4.8
Dec.	26	50.4	3	56.3	+17.7	2	50.5	+ 0.2
Year	235		52		+126.7	28		+115.7

(See References 5 and 7 for details)

or less, as moderately smoggy those with an index of 6 to 9, as severely smoggy those with an index of 10 or greater.

In Table 2 it is shown that moderately smoggy days had slightly more respiratory and cardiac deaths than did the nonsmoggy, but this increase in smog deaths reached truly significant proportions when the smog index passed the 10 level.

Table 2 also presents results of a similar correlation for the period from August 17, 1953, to December 31, 1954. In this period the day-by-day data included deaths from influenza, pneumonia, bronchitis, asthma, and cardiac conditions (Code numbers 460–502, 5271, 241, 410–422, 434, 440–7). Correlation here was made with daily maximum values for "total oxidant" as supplied by Professor A. J. Haagen-Smit of California Institute of Technology. Since preliminary examination indicated a rise in daily deaths at "oxidant" values above 0.2 ppm in the Los Angeles atmosphere, correlation of "oxidant" values greater than 0.2 ppm and 0.2 or less was made with day-by-day cardiac and respiratory deaths (handled as described above for the 1947–1949 period). Adjustment was made to a nonsmoggy mean of 50 for the "all ages" correlation, to 12 for the "all ages below 65" and to 36 for the "65 and over."

Difficulty was encountered in supplying such equalizing corrections to the 1953–1955 data, for the general worsening of the smog situation has left several of the worst smog months with few or no smog-free days to serve as nonsmoggy controls. Proper correction for such months was obtained by anchoring them to the nearest month with a stable number of smog-free days. Table 3 indicates the derivation of the proper correction factors for use in such cases, such derivation being based upon 5-year average values (death data available for 1955 covered only ages 65 and over).

It has been suggested that the frequent association of smogs with excessive heat may give an erroneously high smog-death correlation, since the excess deaths may have been brought about by heat. It must be pointed out, therefore, that days with a maximum temperature above 96° F. numbered 0 in 1947, 1 in 1948, 4 in 1949, 4 in 1953, and 0 in 1954. Of the 5 days in 1948–1949, one was nonsmoggy and with 6 excess deaths, while the other 4 had a high average SRI smog index of 18 and an average of 12 excess deaths per day. Of the 4 in 1953, one fell in July and outside our period of correlation, while the other 3 had only borderline smog and an average of only 6 excess deaths per day. It is known that severe heat can kill, but severe heat in association with severe smog is still more deadly. The extreme heat period of September 1–4, 1955, has been omitted entirely from our correlations.

It is evident from examination of Table 2 that respiratory and cardiac deaths in Los Angeles County are positively and significantly associated with prevailing atmospheric smogginess above SRI index values of 5 or "total oxidant" values above 0.2 ppm. It seems obvious, therefore, that these limits should represent the maximal degree of pollution allowable from the community health viewpoint. From Table 2 it is seen that this smog hazard applies just as significantly for people below age 65 as for the more elderly.

It is unfortunate that failure to make proper correction for seasonal trends led the State Department of Public Health to state that in their nursing home deaths ". . . the data do not substantiate any such effect . . ." on this ". . . type of patient that would be adversely and immediately affected by

TABLE 2.—STATISTICAL ANALYSIS OF SMOG-DEATH RELATIONSHIP

Smog Index	*Mean No. Day Deaths*	*S.D. of Mean*	*Days*	*Smog Index*	*Mean No. Day Deaths*	*S.D. of Mean*	*Days*	*Diff. of Means*	*Diff. / S.E. Dif.*	X^2
1947–49, All Ages, SRI Smog Index.										
SRI 0–5	41.89	7.18	950	SRI 6–9	43.39	7.33	83	1.50	1.8	0.4
"	"	"	"	10+	45.89	7.26	63	4.00	4.2	12.6
"	"	"	"	6+	44.47	7.52	146	2.58	3.9	7.4
Aug. 17, 1953 to Dec. 31, 1954, All Ages, "Total Oxidant" Basis.										
0–0.2 ppm Ox.	50.02	9.46	229	0.2 ppm Oxidant	52.29	7.89	273	2.27	2.9	4.8
Same Period, All Ages Below 65 Years.										
0–0.2 ppm Ox.	12.22	4.87	229	0.2 ppm Oxidant	13.43	4.56	273	1.21	2.9	5.5
Same Period, All Ages 65 and Over.										
0–0.2 ppm Ox.	36.21	6.38	229	0.2 ppm Oxidant	37.57	6.57	273	1.35	2.34	6.0
Jan. 1 to Sept. 30th, 1955 (Omitting Sept. 1–4), Age 65 Years and Over.										
0–0.2 ppm Ox.	36.11	6.89	129	0.2 ppm Oxidant	38.21	7.95	140	2.10	2.3	1.6
Aug. 17, 1953 to Sept. 30, 1955 (Omitting Sept. 1–4, 1955), Age 65 Years and Over.										
0–0.2 ppm Ox.	36.15	6.70	358	0.2 ppm Oxidant	37.79	7.07	413	1.64	3.3	7.3

TABLE 3.—CORRECTION FACTORS FOR DAILY DEATHS OF SMOG SEASON

	1947	*1948*	*1949*	*1947–9*	*1953*	*1954*	*5-year*	*Correction*
JUNE								
Clear	36.8(30)	39.2(30)	43.0(27)	39.7		51.9(10)	42.7	−1
Smoggy	——	——	45.7(3)			54.1(20)		
JULY								
Clear	38.3(26)	37.4(26)	42.1(28)	39.3		——	42.3	0
Smoggy	41.0(5)	34.2(5)	43.0(3)			58.8(31)	(estimated)	
AUGUST								
Clear	38.6(31)	37.2(24)	42.7(16)	39.5	45.0(5)	44.3(8)	41.4	+1
Smoggy		37.6(7)	43.2(15)		30.0(12)	48.7(23)		
SEPT.								
Clear	38.6(22)	34.1(15)	40.8(14)	37.8	43.0(1)	36.5(2)	38.5	+3
Smoggy	37.4(8)	39.1(15)	47.0(16)		50.2(29)	51.3(28)		

(Figures in parentheses indicate number of days.)

air pollution"[3]. We have extended our above-described technique for the elimination of normal seasonal trends from the day-by-day nursing home deaths listed in their appendix Table 1, leaving the July death numbers undisturbed, adding 1/42 to those of August, 3/42 to those of September, subtracting 3/42 from those of October and 15/42 from those of November. These corrections are in accordance with our Table 3 extended to include October and November. Correlation of the seasonally corrected nursing home deaths with Haagen-Smit's total oxidant values from July 3 to November 21, 1955 (but omitting the period of excessive heat from August 31 to September 8) gave the following results:

13	days,	oxidant	values	under	.2	ppm,		averaged	4.72	deaths.
23	"	"	"	of	.2	to	.39 ppm	"	4.95	"
38	"	"	"	of	.4	to	.59 ppm	"	5.22	"
41	"	"	"	of	.6	to	.79 ppm	"	5.86	"
17	"	"	"	of	.8	ppm	and over	"	6.23	"

Calculation of the correlation coefficient on the seasonally corrected nursing home deaths of the whole 132-day period gave: $r = 0.206$, $p = 0.01$, while similar calculation on the 22 uncorrected days of September (omitting the 8 days of excessive heat) gave: $r = 0.191$, $p = 0.04$. Therefore, it certainly cannot be said that ". . . the data do not substantiate any such effects. . . ." Indeed, the strong trend toward a positive and graded association between nursing home deaths and daily oxidant maxima here demonstrated renders it most probable that further extension of the survey period would provide correlation values well beyond the realm of reasonable chance occurrence.

Since the 1949 association was between deaths and the Stanford Research Institute's smog index, and since the smog index is based upon meteorological factors predisposing to smog formation rather than upon actual air analysis of polluting materials, it seems advisable to relate the SRI index directly with actual air analyses. Fortunately Mr. Bartel of the U.S. Rubber Co., has supplied us with ozone maxima for 148 days of 1949[2]. Table 4 indicates the highly significant relationship existing between these ozone values and the SRI smog index values. Correlation coefficient found for 194 days of matching ozone and SRI smog index values was $r = 0.64$, $p = 0\pm$.

Correlation coefficients calculated for certain parts of the series covered in Table 2 gave:

August 17, 1953—December 31, 1954	(502 days)	$r = 0.08$, $p = 0.03$
September only, 1949	(30 days)	$r = 0.949$, $p = 0+$
" " 1953	(30 days)	$r = 0.837$, $p = 0+$
" " 1954	(30 days)	$r = 0.343$, $p = 0.016$

There no longer exists a reasonable doubt that Los Angeles smogs are indeed related to very considerable increases in respiratory and cardiac deaths. In *no* adequate test period were these deaths *less* frequent on smoggy days than on nonsmoggy days; always the mean numbers of such deaths were found to be greater on the smoggy days of every test period. Nor are such excess deaths limited to elderly

people: younger age groups also share significantly in the smog periods.

In sum total, this Los Angeles hazard is represented by 240 excess respiratory and cardiac deaths in the year 1949, by 281 in the last 137 days of 1953, and by 334 in the year 1954. It should be born clearly in mind that this is merely one measurable index of smog damage, that its total of non-fatal ill-health and chronic damage in the respiratory tract must far outweigh these deaths in community importance.

If we add to these Los Angeles findings the Cincinnati survey results, which clearly relate lung cancer incidence to exposure to urban motor exhaust fumes and general urban air pollution[6], we begin to see the outlines of a community hazard calling for the most effective remedial measures available. The Los Angeles situation is indeed so severe and so fraught with health hazards to the area's residents that any pollution control program should be put on the compulsory health basis that alone can provide it with the necessary over-riding authority.

Recent emphasis (Stokinger[8]) has been given to evidences of ozone toxicity for bacteria, molds, experimental animals and human beings, with the result that maximal allowable concentrations considered safe for industrial in-plant workers were lowered in 1954[1] from the former 1.0 ppm to 0.1 ppm (barely detectable by those with a keen sense of smell). Levels of 0.2 ppm definitely increase guinea pig death rates after 7 to 8 months of exposure, while those animals also seem slightly harmed even by 0.1 ppm concentrations after many months of continuous exposure (Wilska[11]). Bacterial and mold growth is inhibited by 0.2 ppm ozone concentrations. Damage to succulent plants begins at 0.1 ppm ozone or oxidant and is severe at 0.2 ppm (Went[10]).

TABLE 4.—RELATION OF SMOG INDEX[7] TO OZONE CONCENTRATION IN AIR[2]

SRI Smog Index	*No. of Test Days*	*Ozone Parts Per 100 Million of Air*			*Diff. Mean*	
		Aver.	*Mean*	*S.D. of Mean*	*S.E. Diff.*	*X² Values*
0	23	9.7	13.00	8.21		
1	21	16.0				
2	25	22.8			5.91	22.5
3	12	22.3				
4	15	23.3		9.64		
5	8	28.2	23.36			
6,7	16	35.5			8.08	19.6
8,9	10	37.1				
10+	18	41.6	39.27	10.08		
All	148					

Ozone toxicity manifests itself in animals and people primarily by irritation and swelling in the cells lining the air passages. Such swelling in the smallest air passages next to the lung's air sacs interferes seriously with their proper ventilation and is the direct cause of death. Other toxic materials such as sulfuric acid mists or the oxides of nitrogen may act similarly in the air passages. Just what connection there might be between such cellular irritation and the generation of lung cancer is not known, but it is significant that such toxicity in most cases means direct interference or blockage of many of the intracellular enzymatic and catalytic systems that form the basis of the vital cellular processes.

The evidences of slow respiratory tract damage in healthy animals continuously exposed for months to ozone concentrations as low as 0.2 ppm (or even 0.1 ppm) makes it imperative that respiratory and cardiac sickness and deaths be still more closely examined for the recent years of steadily worsening smogs in the Los Angeles area. Even without any further evidences than is here presented, there seems ample justification for the imposition of a firm smog-control program aimed at the prevention of atmospheric ozone concentrations above 0.2 ppm (and perhaps even lower) when the area shall have reached complete development.

Los Angeles is not the only urban area now afflicted with damaging ozone (or oxidant) smogs arising largely from the unburned hydrocarbons of liquid-fuel motor exhausts. Cincinnati experienced a number of ozone smogs in the Fall of 1956, the one of October 15 estimated to have been close to the 0.5 ppm ozone level at which Los Angeles calls its First Alert. Here would seem to be an urban community health problem of major proportions.

Summary: Ozone or oxidant-type smogs, now known to be formed by the action of sunlight upon stagnant inversion air masses containing unburned hydrocarbons and nitrogen oxides from liquid-fuel motor exhaust fumes, have been present in Los Angeles for more than a decade and are now appearing with increasing frequency in other American cities as the density of motor transport vehicles increases.

Although ozone was formerly considered a harmless (and perhaps beneficial) atmospheric ingredient, it is now recognized that concentrations of it above 0.2 ppm are potentially harmful to exposed plant and animal life. Its maximal allowable limit for industrial in-plant workers has recently been reduced from 1.0 ppm down to 0.1 ppm (barely detectable by a keen sense of smell).

The present report shows a clearly significant association between Los Angeles smogs and rises in day-by-day respiratory and cardiac deaths in the exposed population. There no longer exists a reasonable doubt that this smog-death relationship is real and of significant proportions. The community health hazard thus generated calls for prompt and energetic measures to lessen pollution of urban atmospheres with liquid-fuel motor exhaust gases, as well as establishing the best possible control over all other known polluting sources.

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EXHIBIT C

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Tobacco Smoking, Motor Exhaust Fumes, and General Air Pollution in Relation to Lung Cancer Incidence

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The rapidly rising incidence and death rates from lung cancer have now brought this disease into the pandemic category (3) and have rendered imperative a searching evaluation of all major causative factors. Amelioration or removal of such causative factors seems necessary for control of the disease's advance, since only in a minor percentage of cases is diagnosis made early enough for surgery to be curative. The survey results here presented represent a limited effort at a separate evaluation of the major factors most closely associated with the disease incidence and indicate the likelihood of a contributing role for motor exhaust fumes.

The finger of suspicion has now been pointed at three types of pollution: cigarette smoke, motor exhaust fumes, and general urban air pollution. Certain occupational dusts and fumes have been shown to be closely associated with lung cancer in exposed workers, but the total of all such occupational cancers is insignificant amid the widespread prevalence of the disease today. On the other hand, cigarette smokers seem definitely more prone than do nonsmokers to develop this type of cancer; and its over-all prevalence among industrialized urban populations—more exposed to motor exhaust fumes and general urban air pollution—is fourfold higher than among rural residents. It is most unfortunate that many proponents of tobacco smoking etiology have disregarded the possibility that all factors work in synergy to pyramid the disease incidence in areas of atmospheric pollution and in the more exposed sex (males being more exposed to all factors).

In reporting our 1946 studies (14, 16) showing lung cancer to be twice as prevalent among men living in polluted industrialized areas as in the clean suburbs of Chicago and Cincinnati, we remarked: "One would be inclined to look elsewhere for a factor which is working synergistically with outdoor air pollution to affect the respiratory tracts of men in particular. One at once thinks of tobacco smoke in this connection, for the percentage of men who smoke is almost three times as great as that of women. . . . It is therefore quite possible that the really alarming respiratory hazard men face in urban areas of heavy air pollution may be due to the combined and cumulative effects of such pollution in conjunction with the chronic irritational action of tobacco smoke."

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Stocks later reported (20) a direct relationship of the prevalence of lung cancer to the size of the city and to urban population density in Britain, remarking: "The facts . . . seem to fit in with the hypothesis that atmospheric pollution by smoke is an important factor *on which tobacco smoking is interposed*. . . . This would mean, in effect, that smoking is more dangerous to a town dweller than to a country dweller."

Materials clearly carcinogenic for experimental animals have been isolated from polluted city atmospheres (2, 8, 9, 12, 13, 19), from tobacco smoke (6, 18), from motor exhaust fumes (10, 11), and from the smoky burning of a large variety of organic materials. Thus, when statistical studies show a direct parallelism between lung cancer prevalence in men and the degree of air pollution prevailing in the air they breathe, there would seem to be grounds for a strong suspicion that these known cancerigenic agents in the air are working slowly through the years. In Chicago, for instance, lung cancer death rates were found in men to reach their peak a full decade earlier in life among those men living in the city's most polluted districts than among those living in its cleaner suburbs (14, 16).

World-wide attention has now been focused recently upon the tobacco smoking aspects of lung cancer causation by two publications, one in America (7) and one in Britain (5). These two publications set forth the result of the most extensive smoking-cancer surveys yet conducted, with results generally verifying the more limited previous surveys of many other investigators. All agree in indicating lung cancer to be sharply more preva-

lent among smokers than nonsmokers. Unfortunately, however, all share also a common failure to consider the part other forms of air pollution may have played in the lung cancer causation under study by them. Their surveys in every case were carried out quite devoid of controls which might have segregated (in part at least) the tobacco smoking and the polluted air factors in the disease causation. All smoking-lung cancer surveys made to date have dealt with nonrepresentative, specially selected groups of subjects and have been severely criticized by Berkson (1) as inadequate for the drawing of valid conclusions of a general nature.

OHIO URBAN-RURAL TOBACCO SMOKING SURVEY

Being conducted by the University of Cincinnati College of Medicine in a sincere effort to find out just what part tobacco smoking and urban air pollution play in the rapidly rising lung cancer death rates. This is purely a fact-finding survey in the interests of human health,—it is in no way concerned with the Tobacco Industry or an Anti-Smoking Crusade.

Name..... ..... Address.....
Street Zone City

..... (date) (age) (sex) (color) (location of home, if different from above)

Place of Residence	1955	1954	1953	1952	1951	1950	1949	1948	1947	1946
Occupation										
Smoking—average number of cigarettes, cigars, or pipefuls per day.										
Cigarettes										
Cigars										
Pipefuls										
Estimate of miles traveled per year by motor vehicle (car, bus, truck, etc.)										

Smoking before 1946: what.....; How much .....; No. of years..... 13

CHART 1.—Questionaire form used in survey

OHIO URBAN-RURAL SURVEY

In planning a survey which would incorporate controls for a separate evaluation of the major factors and would be representative of the general population, we designed it to cover three contrasting Ohio population groups—the dirtier, Basin districts of Cincinnati, the city's cleaner suburbs, and rural populations living in the cleaner country air of the state's rural counties. Items of information covered in the survey included sex, age, color, place and duration of residence, occupation, tobacco smoking history, and an estimate of annual motor travel mileage (Chart 1).

Survey information on living populations was obtained entirely by house-to-house visitation in the Basin districts and by a combination of house visitation and telephone calls in the suburban and country districts where almost all householders have telephones. In all survey districts, well over half the family survey information was provided by the housewife, the adult male members of the household being away at work during the interrogator's working hours. Evening telephone calls provided contact with most of the householders having no informant available during the working day. A housewife's brutal murder by a door-to-door itinerant during the later course of the Basin survey gave rise to a general suspicion of all unknown doorbell-ringers and temporarily curtailed this section of the survey somewhat short of its intended scope.

Although there will be those who object to our use of family survey information obtained so largely from the housewife, its accuracy is probably about as great as could have been obtained directly from each family adult, as long as it concerns memory reporting of long-past events. The alternative, a forward-progressing written daily log kept by each surveyed individual, also allows a strong possibility of bias by its daily emphasis on a given environmental factor such as tobacco smoking through the necessary months or years.

Careful checking by the interrogators whenever possible indicated a reasonably close agreement between the housewife's estimate of the husband's smoking and his own estimate.

Although unable to carry out a purely random sampling of smoking and driving habits in the living population groups under study, we achieved what seemed the best compromise within our means. The Cincinnati Basin area comprises the Ohio River and Millcreek low-lying bottoms where general urban air pollution sources are greatest and natural ventilation poorest. Night-time windless weather periods of temperature inversion usually hold the pollution blanket down around these Basin residents as the air they must perforce breathe. Since our survey dealt with only the white population, it did not include the city's worst slum areas. For convenience we chose the major white population tenement area bounded on the west by Elm Street, on the north by Clifton Avenue, on the east by Sycamore Street, and on the south by Twelfth Street. Within this area an apartment-to-apartment canvass was made of white residents age 20 years or over. With regard to housing, economic status, and generally prevailing air pollution, this district is fairly representative of the entire Basin area inhabited by white residents.

Since the lung cancer death cases subjected to survey represented all such occurring in the total area populations for a 9-year period, it was necessary that our living-person survey be related to the total living area populations of the Basin and suburban areas if we were to apply valid significance tests to any area differences found. Our suburban survey included one white man aged 40+ years for each 65.2 men in the total living population, so we extended our Basin survey until we also had one such person for each 65.2 in the Basin living population. In thus extending our Basin survey (previously curtailed by the housewife's murder) we chose four discrete Basin neighborhoods well away from the previously described major central area (Worth Street in the East End, and portions of Camp Washington, Cumminsville, and Fairview).

The suburban living-person survey covered every fourth household with listed telephone on approximately 40 streets of the city's cleaner areas in Price Hill, Westwood, and Cheviot. No significant differences were noted in the over-all smoking habits of the Basin and suburban men set forth in Table 1.

Final tabulations presented in Table 2 include *only those with at least 10 years' residence in the given area*. For the age groups of the white males from 40 years upwards, for instance, this meant disregarding only 4 per cent from the suburban survey, 6 per cent from the Basin, and 9 per cent from the rural.

Information on residents dying of respiratory tract cancer during the 9-year period (1947–1955) was obtained directly from the death certificates, from hospital records, and from near relatives or close friends. Survey histories were obtained for 76 per cent of all white resident cancer victims in the urban districts and about 28 per cent in the rural districts. All proved to be long-term (over 10 years) residents of the given survey areas, although not always of the particular street address. Throughout this article, the term "lung cancer" is loosely used to denote all primary cancers of the respiratory tract (#161-4 of the International List of Causes of Death). Histological diagnosis was not available in a majority of cases and was not recorded in our survey.

TABLE 1

SUMMARY OF SMOKING HABITS OF WHITE MALES SURVEYED

	Non-smokers (per cent)	Pipe and cigars (per cent)	Cigarettes (per cent)	Total (per cent)
Basin	23.3	15.1	61.6	100.0
Suburban	21.5	15.6	62.9	100.0
Rural	37.2	15.9	46.9	100.0

Table 2 in its upper third summarizes the survey findings for white men of Cincinnati's cleaner areas (Census tracts 45–59, 62–5, 73, 75, 79–85, 93–102, 105–9). By restricting the tabulation in Table 1 to age decades from 40 years upward, we were able to deal mainly with stabilized smoking experiences of 15 years or more. Any individual who had quit smoking less than 10 years previously was listed according to his earlier smoking habits. Smoking combinations including cigarettes were listed always under the appropriate cigarette category. For those smokers "rolling their own," one bag of tobacco was considered as the equivalent of one pack of ready-made cigarettes.

The middle third of Table 2 carries the summated data on white males of Cincinnati's more polluted Basin districts (Census tracts 1–29, 43–4, 60–1, 74, 76–8, 86–7, 90–1, 103–4.

The final third of Table 2 carries the survey data on white males of eighteen Ohio rural counties located at least 40 miles from sizeable industrialized urban centers (Adams, Brown, Coshocton, Darke, Defiance, Geauga, Highland, Hocking, Holmes, Mercer, Monroe, Morgan, Noble, Paulding, Perry, VanWert, Vinton, Williams). The

rural living-population survey was limited to residents of Brown county lying 40–60 miles east of Cincinnati and with no city of as much as 2500 population. To obtain even minimal numbers of lung cancer deaths in the rural survey, a list of all such recorded deaths for the 9-year period, 1947–1955, was first obtained from the State Vital Statistics Section, names of victims and next of kin from county records as far as possible for direct questioning, with final recourse to the survey lack of adequate numbers reduces the Chi-square value to a questionable probability level (Table 3).

Cigarette smoking, when compared with nonsmoking, is also associated with an increased frequency of lung cancer deaths to a significant degree in all population groups. Application of the test for a regression of the proportion of deaths on the daily numbers of cigarettes smoked indicated also a significant association (4) (Table 4).

TABLE 2

NUMBERS OF WHITE MALES SURVEYED,* BY AGE, SMOKING HABITS, AND ANNUAL MILEAGES DRIVEN

Pop. ch.	1930 pop.	Age	Annual mileage driven	No smoking		Pipe and cigars		<15 cig/day		15–35 cig/day		>35 cig/day		Totals	
				Living	Ca. dead	Living	Ca. dead	Living	Ca. dead	Living	Ca. dead	Living	Ca. dead	Living	Ca. dead
Cincinnati suburban area	12,200	40–49	Total	34	0	13	1	99	2	130	9	11	3	288	17(3)†
			<12,000	26	0	11	1	17	2	106	5	6	3	166	11
			>12,000	8	0	2	0	3	0	24	4	5	2	44	6
	11,947	50–59	Total	45	3	22	5	25	4	50	32	6	14	155	58(24)
			<12,000	37	1	19	3	23	2	73	24	2	6	156	36
			>12,000	8	2	3	0	2	2	14	8	4	8	39	20
	11,761	60+	Total	40	14	30	26	22	14	38	46	5	23	151	123(36)
			<12,000	34	12	27	24	20	12	32	33	5	18	129	99
			>12,000	6	2	3	2	2	2	6	13	0	5	22	24
	35,488	40+	Total	117	17	65	32	67	20	225	87	20	42	544	198(63)
			<12,000	97	13	57	30	60	16	211	62	11	27	451	148
			>12,000	20	4	13	2	7	4	14	25	9	15	93	50
Cincinnati Basin area	10,544	40–49	Total	27	2	7	0	10	0	101	8	10	10	173	28(6)
			<12,000	23	1	7	0	8	0	93	3	9	10	147	18
			>12,000	2	1	0	0	2	0	23	5	1	4	33	5
	8,963	50–59	Total	24	1	17	3	9	4	61	41	14	18	185	67(10)
			<12,000	22	1	16	3	7	4	54	34	12	11	111	53
			>12,000	2	0	1	0	2	0	7	7	2	7	14	14
	12,078	60+	Total	62	10	49	19	18	14	49	47	7	28	185	128(30)
			<12,000	61	10	45	17	17	14	49	38	7	26	179	107
			>12,000	1	0	4	2	1	0	0	9	0	4	6	15
	31,085	40+	Total	113	13	73	28	37	18	231	96	37	66	485	215(55)
			<12,000	106	12	68	20	34	18	201	77	28	51	457	178
			>12,000	5	1	5	2	3	0	30	19	3	15	46	37
Ohio rural areas	24,787	40–49	Total	44	0	13	2	26	1	68	3	13	4	174	11(3)
			<12,000	27	0	11	1	24	1	57	1	5	2	107	5
			>12,000	17	0	4	2	12	0	33	2	7	2	85	6
	22,043	50–59	Total	46	0	22	1	33	1	55	7	13	7	187	16(45)
			<12,000	35	0	15	0	23	1	42	5	7	5	135	11
			>12,000	11	0	10	1	10	0	13	2	6	2	52	5
	24,960	60+	Total	118	11	46	6	40	2	91	19	5	7	230	44(128)
			<12,000	104	10	39	6	26	2	10	18	3	6	200	39
			>12,000	14	1	7	0	2	0	5	3	2	1	30	5
	81,790	40+	Total	206	11	80	10	111	4	110	23	35	18	559	71(181)
			<12,000	166	10	66	7	85	4	73	21	15	13	412	55
			>12,000	42	1	21	3	26	0	45	7	15	5	147	16

* Including only men with 10+ years' residence in given area.

† Numbers in parentheses represent deaths without survey contact.

records of practicing physicians in the counties listed. This phase of the rural survey will not be completed for quite some time, but the results already at hand seem worthy of presentation at this time.

In consultation with two Cincinnati biometricians, the following statistical analysis of the data presented in Table 2 was carried out.

Pipe and cigar smoking, when compared with nonsmoking, is associated with an increased frequency of lung cancer deaths to a significant degree This finding holds true for Cincinnati Basin and suburban white men, but in the Ohio rural

Significant degrees of association were also found to exist between cigarette smoking and increased lung cancer death frequency when separate calculations were made for those men driving less than 12,000 miles per year in urban traffic and for those driving more than this mileage (Table 5).

The graded character of this significant association of cigarette smoking with increased frequency of lung cancer deaths is shown in Chart 2, in which lung cancer deaths included in the survey are expressed as a percentage of total living and dead surveyed populations in the various areas An added point of significance, shown

in Chart 2, is the heightening of lung cancer death percentages among nonsmokers and both categories of cigarette smokers in association with driving mileages above 12,000 mi/yr among both urban population groups.

TABLE 3

COMPARISON OF PIPE AND CIGAR SMOKING WITH NONSMOKING AMONG WHITE MALES SURVEYED

	Nonsmokers	Pipe and cigars	Total
Cincinnati Basin men, 40+ yrs.:			
Living	113	73	186
Cancer deaths	13	22	35
Totals	126	95	221
$\chi^2 = 6.791$ (D.F.* = 1) $.01 > P > .001$			
Cincinnati suburban men, 40+yrs.:			
Living	117	85	202
Cancer deaths	17	32	49
Totals	134	117	251
$\chi^2 = 8.627$ (D.F. = 1) $.01 > P > .001$			
Ohio rural men, 40+yrs.:			
Living	208	89	297
Cancer deaths	11	10	21
Totals	219	99	318
$\chi^2 = 2.922$ (D.F. = 1) $.1 > P > .05$			

* D.F. = degrees of freedom.

Driving mileages above 12,000 mi/yr as compared with lesser driving mileages are associated to a significant degree with increased lung cancer death frequency among both urban survey populations but not among the rural (Table 6).

General urban air pollution, to which Basin residents are exposed much more than residents of cleaner suburban areas, on the basis of the data at hand seems associated with a heightening of lung cancer death frequency to a degree of questionable significance if all ages above 40 years are included in the calculation. The association becomes more clear and of significant degree, however, if the calculation is limited only to men of ages 40–59 years when driving habits are more sharply delineated (Table 7). It is fully realized, in making these calculations, that the lack of random sampling in the area surveys enters a degree of doubt as to the validity of any conclusions to be drawn.

Survey data similar to those presented in Table 2 were also collected on white women of the three areas (Table 8). Lung cancer frequency among the women was at levels too low for the application of valid significance testing of differences. There is *as yet* no evidence (from our survey data) of a tendency of lung cancer frequency in women to rise in association with cigarette smoking. It is of interest that urban nonsmoking men exhibit lung cancer frequencies not greatly different from those exhib-

TABLE 4

COMPARISON OF CIGARETTE SMOKING WITH NONSMOKING AMONG WHITE MALES SURVEYED

	Nonsmokers	1–24 cig/day	>24 cig/day	Totals	D.F.	χ^2	P
Cin. suburban men, 40+yr.:							
Living	117	322	20	459			
Cancer deaths	17	107	42	166			
Totals	134	429	62	625			
Source							
Total					2	67.500	$< .001$
Linear regression					1	36.141	$< .001$
Quadratic regression					1	31.359	$< .001$
Cin. Basin men, 40+yr.:							
Living	113	268	31	412			
Cancer deaths	13	114	66	193			
Totals	126	382	97	605			
Source							
Total					2	75.346	$< .001$
Linear regression					1	75.833	$< .001$
Quadratic regression					1	− 0.487	
Ohio rural men, 40+yr.:							
Living	208	229	33	470			
Cancer deaths	11	32	18	61			
Totals	219	261	51	531			
Source							
Total					2	37.253	$< .001$
Linear regression					1	22.010	$< .001$
Quadratic regression					1	15.243	$< .001$

ited by the women, suggesting the lack of any purely sex factor in the disease incidence.

One point not answered by the data thus far presented is whether tobacco smoking per se is associated with a "triggering off" of lung cancer development, or whether a basic biological factor may be leading to both tobacco smoking and cancer development. The latter is a conceivable possibility, but it is not reasonably conceivable that this relationship would involve cancers of the bronchial mucosa and not those of tissues not directly exposed to air-borne irritants or carcinogens.

In attempting to explore this point in our Cincinnati survey, we considered it wise to exclude from consideration cancers of the digestive and excretory systems and to limit ourselves entirely to primary malignant tumors of the pancreas, prostate, central nervous system, and bones (#157, 177, 193, and 196, International List of Causes of Death). Cincinnati resident deaths from these causes for 4 years (1952–55) were listed, and survey contact was obtained for 26 white males aged 50–59 and for 28 aged 60–69. The percentages of these falling into the various smoking categories are shown in Table 9 and compared with analogous percentages for the combined Cincinnati suburban and basin living populations and lung cancer deaths.

Men dying of these special types of cancer (pancreas, etc.) exhibited smoking habits essentially

TABLE 5

CLASSIFICATION OF CIGARETTE SMOKING ON BASIS OF ANNUAL AUTOMOBILE MILEAGE

	<12,000 MI/YR			>12,000 MI/YR		
	D.F.	χ^2	P	D.F.	χ^2	P
Cin. suburban men, 40+yr.:						
Total	2	46.000	$<.001$	2	10.898	$.01<.001$
Linear regression	1	30.857	$<.001$	1	10.651	$.01<.001$
Quadratic regression	1	15.143	$<.001$	1	0.247	$.7<.5$
Cin. Basin men, 40+yr.:						
Total	2	67.941	$<.001$	2	12.185	$<.001$
Linear regression	1	59.446	$<.001$	1	10.495	$<.001$
Quadratic regression	1	8.495	$.01<.001$	1	1.690	$.2<.1$
Cin. rural men, 40+yr.:						
Total	2	32.749	$<.001$	2	5.669	$.1<.05$
Linear regression	1	17.322	$<.001$	1	4.328	$.02<.05$
Quadratic regression	1	15.427	$<.001$	1	1.341	$.3<.2$

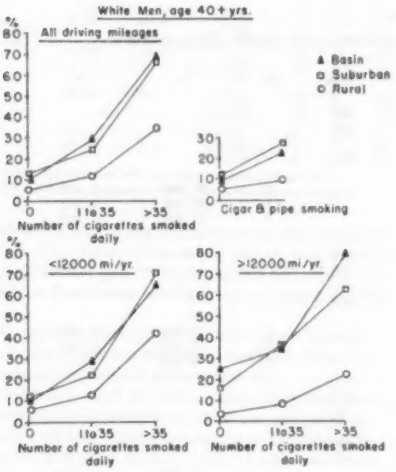

CHART 2.—Surveyed lung cancer dead as percentage of total living and dead surveyed.

TABLE 6

RELATION OF DRIVING MILEAGE TO LUNG CANCER DEATHS AMONG WHITE MALES SURVEYED

	<12,000 mi/yr	>12,000 mi/yr	Totals
Cincinnati Basin men, 40+yrs.:			
Living	437	48	485
Cancer deaths	178	37	215
Totals	615	85	700
$\chi^2=7.477$ (D.F.=1) $.01>P>.001$			
Cincinnati suburban men, 40+yrs.:			
Living	451	93	544
Cancer deaths	148	50	198
Totals	599	143	742
$\chi^2=6.162$ (D.F.=1) $.02>P>.01$			
Ohio rural men, 40+yrs.:			
Living	412	147	559
Cancer deaths	55	16	71
Totals	467	163	630
$\chi^2=0.477$ (D.F.=1) $.5>P>.3$			

similar to those of the living population controls, in sharp contrast to the much higher cigarette smoking percentages of those dying of lung cancer. Application of χ^2 tests to the observed frequencies indicated no significant differences between the smoking habits of the special-type cancer victims and the living populations, but it showed a sharply significant difference between the lung cancer victims and those succumbing to the special-type cancers having no polluted air contact (Table 10).

We cannot, therefore, entertain the hypothesis of a basic biological factor as possibly responsible for both the smoking and heightened lung cancer incidence in the smokers. These findings strengthen the likelihood of real significance residing in the observed relationships. Tobacco smoking would thus seem significantly related to the development of lung cancer, and this smoking-cancer relationship seems further heightened for those with high urban motor driving mileages and perhaps still further for those residing in Cincinnati's polluted Basin districts.

The data here presented will make it difficult for Kotin (or any other member of the Scientific Advisory Board of the Tobacco Industry Research Committee) to continue holding that there is ". . . no convincing evidence that tobacco possesses the necessary qualifications for the initiation and promotion of lung cancer . . . ," or that the use of tobacco is ". . . capable of playing only a secondary role in the increase in lung cancer rates" (8). It would now seem most likely, rather, that the heavy dosing of the respiratory mucosa with tobacco smoke for many hours each day acts as the dominant etiologic factor in much of today's lung cancer, with motor exhaust fumes and general urban air pollution *as yet* perhaps serving only to aggravate the tobacco-smoking effects.

The only other survey approaching this one in complete coverage of all major factors associated with lung cancer incidence is that of Stocks *et al.* (20) in England. It is unfortunate that Stocks and his co-workers used hospital and clinic patients as representative of the urban and rural populations, instead of making actual house-to-house surveys as we have now done. The errors of expecting hospital or clinic patients to represent the general populations from which they derived have already been emphasized (17).

DISCUSSION

Most timely and of great significance in today's serious lung cancer situation is Otto Warburg's recent paper "On The Origin of Cancer Cells" (22). In it Warburg presents the case for nonspecific and irreversible damage to intracellular enzymatic systems of the mitochondria as the first step in the change from a normal to a cancer cell. Such changes in the mitochondrial metabolism have been shown to hold indefinitely through many successive cellular generations and to become progressively greater with repetition of the damaging episodes. Labile sulfhydryl and oxidant-sensitive linkages make the epithelial tissues lining the air passages very vulnerable indeed to such intracellular damage from polluting materials in the air breathed.

Herein lies a possible and very disturbing ex-

TABLE 7

DRIVING MILEAGE AND LUNG CANCER DEATHS AMONG ALL WHITE MALES SURVEYED AND AMONG THOSE 40–59 YEARS OLD

	Basin	Suburban	Totals
Basin vs. suburban men, 40+yrs.:			
<12,000 mi/yr			
Living	437	451	888
Cancer deaths	178	148	326
Total	615	599	1214
$\chi^2=2.749$ (D.F.=1) $.1>P>.05$			
>12,000 mi/yr.			
Living	93	48	141
Cancer deaths	50	37	87
Total	143	85	228
$\chi^2=1.685$ (D.F.=1) $.2>P>.1$			
All mileages			
Living	485	544	1029
Cancer deaths	215	198	413
Total	700	742	1442
$\chi^2=2.857$ (D.F.=1) $.1>P>.05$			
Basin vs. suburban men, age 40–59 years only:			
<12,000 mi/yr.			
Living	258	322	580
Cancer deaths	71	49	120
Total	329	371	700
$\chi^2=8.579$ (D.F.=1) $.01>P>.001$			
>12,000 mi/yr			
Living	42	71	113
Cancer deaths	22	26	48
Total	64	97	161
$\chi^2=1.040$ (D.F.=1) $.5>P>.3$			
All mileages			
Living	300	393	693
Cancer deaths	93	75	168
Total	393	468	861
$\chi^2=7.920$ (D.F.=1) $.01>P>.001$			

planation for the significant associations now shown to exist between the various forms of air pollution and the rising lung cancer incidence. The urbanization and motorized mechanization upon which today's civilization is based thus seems to be encountering health hazards of considerable magnitude. Before the days of effective antibiotics and chemotherapy, pneumonia and tuberculosis exhibited the same close relationship to polluted air as is found for lung cancer. Today, lung cancer is the greatest killer among respiratory diseases and is rapidly growing in stature as a health problem. Other forms of chronic, nonfatal damage from breathing polluted air (emphysema, for instance) perhaps carry a much greater over-all hazard than does lung cancer but are more difficult of quantitation because they are less clear-cut and do not directly kill.

Air pollution's mass killing episodes (Belgium, 1930; Donora, 1948; London, 1948, 1952, and 1956) are more dramatic but also perhaps of less over-all importance than this slower damage to the air passages and lungs. Los Angeles' smoggy days are immediately associated with an excess of some 350 respiratory and cardiac deaths each year, as compared with the year's least smoggy days (15), and yet still more importance is perhaps to be attached even there to the more chronic types of pollution damage slowly leading on to the initiation of cancer and perhaps emphysema.

We must now consider the possibility that each nonfatal exposure to polluted air damage may produce irreversible and irreparable cell damage in the respiratory system which could accumulate through the years with repetition of the exposure episodes. This community health problem may thus differ sharply from those associated with infectious disease where tissue recovery is usually complete following each damaging episode. This possibility of irreversible and accumulative damage from breathing polluted air renders imperative an entirely new evaluation of pollution levels safely allowable for exposed persons. Immediate damaging effects in the respiratory system may perhaps no longer serve as the criterion of safety —we must now consider the possibility that re-

TABLE 8

NUMBERS OF WHITE FEMALES SURVEYED,* BY AGE, SMOKING HABITS, AND ANNUAL MILEAGES DRIVEN

GROUP	1950 POP.	AGE	ANNUAL MILEAGE DRIVEN	NO SMOKING		<15 CIG/DAY		15–35 CIG/DAY		>15–35 CIG/DAY		TOTALS	
				Living	Ca. dead	Living	Ca. dead	Living	Ca. dead	Living	Ca. dead	Living	Ca. dead
Cincinnati suburban areas	14,104	40–49	Total	125	6	66	0	30	2	0	1	230	9(1)†
			<12,000	123	6	66	0	28	2	0	1	227	9
			>12,000	2	0	0	0	1	0	0	0	3	0
	12,730	50–59	Total	133	3	30	0	21	2	0	0	184	5(0)
			<12,000	129	3	30	0	21	2	0	0	180	5
			>12,000	4	0	0	0	0	0	0	0	4	0
	13,708	60+	Total	163	13	9	3	1	0	0	0	173	16(8)
			<12,000	165	13	5	3	1	0	0	0	172	16
			>12,000	0	0	1	0	0	0	0	0	1	0
	40,660	40+	Total	421	24	105	3	61	4	0	1	587	32(9)
			<12,000	413	24	104	3	60	4	0	1	579	32
			>12,000	6	0	1	0	1	0	0	0	8	0
Cincinnati Basin areas	10,492	40–49	Total	66	1	32	0	48	0	2	2	150	3(1)
			<12,000	67	1	32	0	45	0	2	2	148	3
			>12,000	1	0	0	0	0	0	0	0	1	0
	9,979	50–59	Total	85	3	24	0	40	1	1	0	150	4(4)
			<12,000	85	3	24	0	40	1	1	0	150	4
			>12,000	0	0	0	0	0	0	0	0	0	0
	13,390	60+	Total	176	17	21	0	13	2	1	0	211	19(4)
			<12,000	176	17	21	0	13	2	1	0	211	19
			>12,000	0	0	0	0	0	0	0	0	0	0
	32,861	40+	Total	329	21	77	0	101	3	4	2	511	26(9)
			<12,000	328	21	77	0	101	3	4	2	510	26
			>12,000	1	0	0	0	0	0	0	0	1	0
Ohio rural areas	25,282	40–49	Total	142	1	40	0	24	2	4	1	214	4(3)
			<12,000	144	1	39	0	21	2	4	1	209	4
			>12,000	2	0	1	0	2	0	0	0	5	0
	22,163	50–59	Total	134	5	19	0	9	0	0	0	160	5(13)
			<12,000	133	5	18	0	9	0	0	0	153	5
			>12,000	4	0	1	0	0	0	0	0	5	0
	35,688	60+	Total	253	27	10	0	5	0	0	0	280	27(59)
			<12,000	252	27	10	0	5	0	0	0	247	27
			>12,000	3	0	0	0	0	0	0	0	3	0
	91,671	40+	Total	515	33	69	0	38	2	4	1	664	36(77)
			<12,000	504	33	67	0	36	2	4	1	611	36
			>12,000	9	0	2	0	2	0	0	0	13	0

* Including only those with 10+ years' residence in given area.

† Numbers in parentheses represent deaths without survey contact.

peated but isolated exposure may eventually lead to accumulated cellular changes of serious importance.

SUMMARY AND CONCLUSIONS

Details are presented of a survey covering residence, smoking and driving habits of living populations and those dying of lung cancer in the basin and suburban areas of Cincinnati and in Ohio rural areas. The findings in this survey give rise to the following deductions and conclusions:

1. Tobacco smoking was found to be significantly related to lung cancer incidence in the subjects of this study, whether or not there was in addition heavy exposure in urban motor traffic or to general urban air pollution.

2. Annual driving mileages above 12,000 miles per year, as compared with lesser driving mileages, are significantly related to lung cancer incidence among urban men, except for those in the heavy smoking category.

3. Lung cancer death frequencies were found significantly higher among Cincinnati's Basin men than among suburban men in this survey.

4. Lung cancer rates in nonsmoking men, urban or rural, did not differ significantly from the low rates found prevailing in women of all groups.

5. Finally, it is suggested that the alarming rise in lung cancer incidence is predominantly a hazard pertaining to urban tobacco smoking, but a hazard intensified for those urban smokers with heavy exposure also in urban traffic.

TABLE 9

SMOKING HABITS AND DEATHS FROM LUNG CANCER AND OTHER CANCERS*

Surveyed population	Age	Non-smokers (per cent)	Pipe and cigar (per cent)	Cigarettes (per cent)
Living white males	50–59	22.0	12.6	65.4
Cancer deaths (pancreas, etc.)	"	23.1	7.7	69.2
Cancer deaths (lung)	"	3.2	6.4	90.4
Living white males	60–69	30.9	22.7	46.8
Cancer deaths (pancreas, etc.)	"	25.0	28.6	46.4
Cancer deaths (lung)	"	8.6	7.9	86.5

* These include primary malignant tumors of the pancreas, prostate central nervous system, and bones.

TABLE 10

RELATION OF SMOKING HABITS TO DEATHS FROM LUNG CANCER AND CERTAIN OTHER CANCERS

	Non-smokers	Cigarette smokers	Totals
Living	117	275	392
Cancer deaths (pancreas, etc.)	13	31	44
Totals	130	306	436
$\chi^2 = .001$ (D.F. = 1) P = .98			
Cancer of lungs	16	230	246
Cancer of pancreas, etc.	13	31	44
Totals	29	261	290
$\chi^2 = 22.018$ (D.F. = 1) P < .001			

	Non-smokers	Pipe and cigars	Cigarettes	Totals
Living	117	69	275	461
Cancer (pancreas, etc.)	13	10	31	54
Totals	130	79	306	515
$\chi^2 = .461$ (D.F. = 2) .5 > P > .3				
Cancer (lungs)	16	19	230	265
Cancer (pancreas, etc.)	13	10	31	54
Totals	29	29	261	319
$\chi^2 = 24.510$ (D.F. = 2) P < .001				

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Mr. LOSER. You may proceed, sir.

Dr. MILLS. I present those as regular exhibits because of the wealth of detailed information in them which I will not take time to present here verbally.

Now, exhibit C, the tobacco smoking, motor-exhaust fumes and general air pollution in relation to lung-cancer incidence, represents a very serious effort to assay the various factors at work in the amazing and very alarming rise in lung-cancer incidence in American cities, much more in the cities than in the country districts, and the finger of suspicion has been pointed very strongly at tobacco smoking, there had been some suspicion of general urban air pollution being a factor also, but there had been no real serious effort at separate evaluation of those factors in this lung-cancer situation.

This report, exhibit C, presents my findings there which, in essence, indicate tobacco smoking, and primarily cigarette smoking, as the major etiological causative factor in lung-cancer incidence, but that tobacco-smoking effect is more than doubled for those urban residents who drive more than 12,000 miles a year on an average in urban traffic.

It is still higher for those tobacco smokers who drive that much and then live in the dirtiest part of the city.

So we have there a very first strong hint that motor-exhaust fumes are a significant factor, mathematically significant also, in the incidence of lung cancer.

You might say that since we are speaking of tobacco smoking this is not a community health problem, but just remember that over 80 percent of the adult men smoke and almost half of the women, so whether you think you are dealing with a class, you are still dealing with the major part of a community.

So that it is a community problem, the accentuation of the lung-cancer hazard by motor-exhaust fumes.

Now, I have spoken of smogs and there was some reference this morning to smogs.

While your bill as printed here speaks of automobile-exhaust gases, with particular reference to the unburned hydrocarbons—and, incidentally, in that respect right now I would strongly suggest that each place where "unburned hydrocarbons" is mentioned it should be "unburned hydrocarbons and other noxious gases"—there is a definite hazard to the unburned hydrocarbons and noxious gases in automobile exhaust directly.

However, the danger there is not so much to the unburned hydrocarbons as it is to carbon monoxide and certain much more irritating gases like the nitrogen oxides.

Those hazards arise in garages and confined areas, tunnels, where the traffic is heavy, where you have the gases themselves achieving real dangerous concentrations.

But if you are concerned with community health hazards, then I feel that the emphasis should not be on the exhaust gases per se, but upon what arises from them in the community atmosphere, and that is why you find always the emphasis on smogs.

Now, some cities of the world do have smog today even where there is very little liquid fuel being burned inefficiently.

Smogs are only hazy atmospheres that have damaging properties, we will say, but when we come to the cities of the world where the major fuel burned is liquid fuel and it is being burned in motor transport vehicles, then we come to a use of the term "smog" that represents the end product of what happens to the exhaust gases when they get into the atmospheric mixing bowl and that is where the work done at California has been very elucidating.

It was mentioned this morning that the smogs occur in clear weather. And, by the way, California is not the only place having the ozone smog now; we have plenty of them in Cincinnati. Other cities are developing them as the motor transport density increases.

But when the unburned hydrocarbons and the nitrogen oxides of the motor exhaust achieve sufficient concentration in what is usually still air over a city, with the sunlight falling on the mixture, then you have the setup for the formation of ozone or the oxidant-type smog.

They are called smog because visibility is always interfered with as those products develop.

You have haze, usually a blue haze, when the ozone comes.

Now, the reason for the emphasis upon these ozone smogs is that ozone is now thoroughly recognized as one of the very most toxic, highly poisonous gases.

Quite contrary to what we used to think in medical circles—ozone as being a beneficial agent—we now are, most of us, pretty well of the opinion that any amount of ozone that can be smelled by a sensitive nose, and that means about one-tenth part per million in the air—anything that can be smelled is too much for a long-term exposure.

In these exhibits that I present here I summarize the references to the literature that have a bearing.

At one-tenth part per million damage begins in various types of biological life, moles, bacteria, seedlings; at two-tenths parts per million the damage becomes significant for the many types of simple life and we begin to have evidences of a rise in the respiratory and cardiac deaths in Los Angeles, for instance, on days that reach that level.

So that what you are asking the Surgeon General here is to set a limit on the amount of unburned hydrocarbons and other noxious gases from motor exhaust.

Really, your limit must arise from some basis of community danger from such exhaust.

On that basis I would refer to Los Angeles as the only place applying a really good reference point at present because in Los Angeles the other sources of the ozone precursors that were previously thrown into the atmosphere in significant amounts have been eliminated one by one.

They have done an excellent job of pollution prevention there for all sources or major sources except the liquid fuels motor exhaust gases.

Those they have not been able to touch except where you have obvious smoking in the axhaust.

As it was brought out this morning, the smoke in an automobile exhaust has very little reference to the total amount of unburned hydrocarbons being put out.

Now, in Los Angeles today there are times when their ozone concentration still exceeds their first alert level of five-tenths part per million in the air of ozone or oxide.

Fortunately, it does not exceed that level nearly as much as it did 1 year and 2 years and 3 years ago. It has gone as high as 1 part per million that that was a really worrisome experience.

But if the Surgeon General were to accept the evidence that indicates that the upper limit of safety for ozone in a community's air for hours of exposure be set at one-tenth part per million and if Los Angeles is still having five-tenths part per million, then it would seem that for an urban community like Los Angeles—and there are situations coming up in plenty of other places—there should be at least 80 percent reduction, and I say preferably 90 percent reduction, in the output of the ozone precursors in motor exhaust gases.

That, you may say, is coming out in a roundabout way. It is the most concrete way there is at present as a basis for action.

As I say, while Los Angeles stands alone as the only good point of reference at present, similar ozone problems are arising elsewhere as traffic density and weather conditions provide for the ozone setup.

So very briefly, then, we know little about the toxicity of exhaust gases except for carbon monoxide.

We know something about the nitrogen oxides, but they seldom achieve dangerous proportions. Carbon monoxide does in garages and tunnels. But the unburned hydrocarbons of exhaust gases, we know almost nothing of their direct toxicity.

We do have much more evidence, not as complete as we would like still, on ozone, but we have evidence there, it is circumstantial, although I think one of the gentlemen present now regard it as a pretty personal circumstance, having submitted himself to a test of toxicity in a chamber, Mr. Griswold, but it would seem that the course of action here should be to set, tentatively at least, the limits for a device or devices, a limit that would aim, if possible, at least 80 percent reduction in the overall output of these gases in automobile exhausts.

Now, frankly, I am here as your witness and my suggestion would be that you not plead with the automotive industry for relief. They have a long-term program going on.

My suggestion would be more in line with the lifetime I have spent as more or less an individual researcher, and that is that some basis be set up to provide aid for independent inventors.

I have a very strong feeling that your answer is more likely to come from individual inventors than from the automotive industry itself.

There is one such in Cincinnati whose invention I have looked at. He did not have money enough; he had to take a job and drop it. I thought it was very promising, but there was no way of pursuing it.

Now, that might be something within your scope as a part of this bill aimed at in some way getting relief from the motor exhaust gas problem.

I think, Mr. Chairman, that that is all I will offer. I shall be glad to answer any questions or try to answer them.

Mr. LOSER. Thank you very much, Doctor, for your very fine statement.

Perhaps other members of the committee would like to ask you a question or two?

Mr. Schenck?

Mr. SCHENCK. Thank you, Mr. Chairman.

I want to express my deep appreciation to Dr. Mills for coming here from the University of Cincinnati. It is so close to my home district.

It so happens that some of my most personal and best friends in the medical profession went to your great school. I have the highest regard for your school.

Dr. Mills, you have mentioned some rather small portions here, per million parts, that would be considered dangerous to health.

I take it from your experience and testimony that you feel this matter is important from the standpoint of public health, even more so than from the standpoint of interstate commerce.

Dr. MILLS. Yes, sir. I regard it as one of the dominant public-health problems today, one that is increasing in importance and severity that has as yet no solution available. Hence its real importance. It is dealing with one of our most worrisome diseases certainly, lung cancer, but not alone that. While you may say it is a public-health problem, it deals with all—I would say all—liquid-fuel motor-vehicle transport. That certainly includes interstate commerce as, shall we say, a minor matter of the total.

Mr. SCHENCK. Of course, Doctor, some of my learned colleagues who are learned in the law, and I am not, may have some legal questions as to the enforcibility of such a law from the standpoint of interstate commerce which you might be perfectly willing to concede is proper from the standpoint of public health.

Not too long ago we had a witness before this committee, a medical doctor, who illustrated this measurement as being something like this: 1 part per million would be equal to 1 standard drop of a medicine dropper in 16 gallons; is that about right?

Dr. MILLS. You have posed me a real question. I would have to do some calculations.

Mr. SCHENCK. When you speak of five-tenths part per million, that brings it down pretty fine. That would indicate that even what someone might consider an infinitesimal amount would still be highly dangerous from the standpoint of public health.

Dr. MILLS. No, sir; I think we are speaking perhaps of that one-tenth part per million with different references. I was referring to it in the atmosphere over the city, the atmosphere people are breathing.

That, of course, is quite different from concentrations in the motor-exhaust gases at the tailpipe. Those gases, of course, are diluted greatly in the atmosphere over a city.

However, it has gotten to the point where, shall we say, nobody in Los Angeles on their bad days are breathing air that is not exhaust gas. They have used up their last cubic mile of fresh air and they are rebreathing now.

Even the motors are not having the fresh air any more. They are using their own rebreathed air.

But the point is that we have a source, shall we say, a small source, but a multitude of small sources kicking out into the atmosphere and then mixing in the atmosphere the people must breath. These, shall we say, are small amounts, but enough in amount so that as the sunlight and this atmospheric mixing bowl does its work, you have dan-

gerous amounts of this one ingredient, ozone, which is the end result of a very, very poisonous gas.

Now, it is that that I think you should be concerned about in your automobile traffic exhaust gases.

The gases themselves are damaging. I think it is the gases themselves that showed up most in our lung cancer survey in Cincinnati because that was the drivers in the traffic stream.

But the greater public-health hazard lies in ozone as a community hazard generated from the exhaust gases. The only way you can control the amount of ozone is by controlling the output of the ozone precursors.

Mr. SCHENCK. Then, Dr. Mills, you feel that the control of the quality of the exhaust gases that are emitted by internal-combustion engines is of great importance to the public health of this Nation?

Dr. MILLS. I do, sir.

Mr. SCHENCK. Do you feel then that the Public Health Service, under the direction of the Surgeon General, should be making very careful calculations looking toward the establishment of safe standards?

Dr. MILLS. Yes, sir; I am sure they are.

Mr. SCHENCK. You feel that this is not just something that ought to be brushed off for future reference?

Dr. MILLS. No, sir; that is why the 15-year research plans sort of irk me. In fact, I don't think I will be tolerating it 15 years, myself. But this seems to me to be a problem of sufficient magnitude for urban communities to warrant a rapid study program and something more than action in an indeterminate future. That is why I was particularly taken with the bill's proposal that the Surgeon General provide his first estimate of those standards within 6 months. I hope you do not ameliorate that.

Mr. SCHENCK. You mean you hope that that is not extended?

Dr. MILLS. Yes, sir.

Mr. LOSER. The gentleman from Indiana, Mr. Beamer.

Mr. BEAMER. Thank you, Mr. Chairman.

I am sorry, Dr Mills, I was not able to hear the first part of your statement. I am very much impressed with your later remarks.

I know from conversing with my colleagues on this committee that you are very much interested in this problem.

I have one very brief question. From your studies, have you any idea that this will entail a large amount of expense on the part of manufacturers of automotive equipment to so construct their engines that they will burn more hydrocarbons and probably have less ill effect upon the traveling public?

Dr. MILLS. There have been various devices of promise, none of them have quite adequate promise yet, and the estimated installed cost of those has been in the range of anywhere from $25 to $50, some as high as $100 a car. Now, that is on existing cars. It should not be anything like that on new cars.

Mr. BEAMER. You feel if it were part of the equipment at the source it would be a small item, so far as the cost of the car is concerned?

Dr. MILLS. Yes; a small item in comparison with what the average car driver has to lay aside for the annual cost of owning and operating a car; yes.

Mr. BEAMER. I have one last question.

In your studies have you differentiated between passenger cars and trucks? Do they use different types of fuel?

Dr. MILLS. The differentiation is more between the gasoline and oil LP gas type of fuel and diesel fuel. The diesel engine is quite a different proposition. Its output will be dominantly the nitrogen oxides and some very irritating aldehydes, more direct irritation, but much less burned hydrocarbon than the other gasoline type of fuel.

Now, there is not too much difference with the gasoline type of fuel as to the size of the vehicle. The large ones, of course, such as our gasoline buses in our cities, are a terrible nuisance, but you understand that they are doing a lot of work in transport.

They may carry 50 people. I doubt if they put out as much, shall we say, bad breath, as 50 cars would, but it is concentrated.

But there is that distinct difference between the diesel type and the gasoline type.

Mr. BEAMER. Would there be any distinction between that type and, shall we say, coal-fired locomotives?

Dr. MILLS. Your question is more or less hypothetical because the coal-fired motor is practically out of existence.

Mr. BEAMER. May I say a coal-fired heating plant of any type?

Dr. MILLS. The coal-fired heating plant—you mean the stationary plant?

Mr. BEAMER. Yes.

Dr. MILLS. A stationary plant can always lick this problem directly as they have made them do in Los Angeles because so long as you are stationary, then you can install collecting equipment and handle the problem.

That is a beautiful demonstration out on the west coast, and that was done more or less with some of the coal-burning locomotives before they went out of existence. When they were forced to use the steam jet smoke consumer they did a pretty good job when they had to.

Mr. BEAMER. I want to thank you, Dr. Mills. This is quite illuminating to those of us who are not chemists.

Mr. SCHENCK. Mr. Chairman, could I add this one comment?

Mr. LOSER. Yes.

Mr. SCHENCK. My longtime friend, Dr. Charles Kettering, was, I know, one of the first directors of research for a great corporation. He said that it always irked him when he had a group of engineers or others who gave him all the reasons why something could not be done and that he was interested in those fellows who did not know that something could not be done so they went ahead and did it.

Dr. MILLS. Yes; he was one of the outstanding examples of an independent inventor.

Mr. SCHENCK. That is right. I do not mean to quote Dr. Kettering verbatim, but that is the substance of his statement and he said it always irked him when he went into a meeting with a group of people and stated a problem and they immediately pulled out slide rules to show why it could not be done.

Mr. LOSER. I wonder if the gentleman from Pennsylvania would like to ask Dr. Mills a question. Dr. Mills is here with a very enlightening statement, Mr. Bush.

Mr. BUSH. Mr. Chairman, I was delayed getting over here and did not hear his statement. I am sure that the questions that have been asked have covered the subject satisfactorily.

Mr. LOSER. Thank you so much, Doctor.

Dr. MILLS. Thank you, Mr. Chairman.

Mr. LOSER. Is Mr. Doughty here?

Mr. Ross V. Doughty is a combustion engineer from Dayton, Ohio. I believe you are with the city, are you not?

STATEMENT OF ROSS V. DOUGHTY, COMBUSTION ENGINEER, DEPARTMENT OF SERVICE AND BUILDINGS, DAYTON, OHIO

Mr. DOUGHTY. Yes, sir; I am the combustion control engineer for the city of Dayton.

In that capacity every day practically we receive complaints from numerous people, from doctors, lawyers, and the citizens themselves, complaining against fumes coming from practically all transportation devices.

We have had complaints on vehicles such as the railroad trains, diesel trains, so to speak, and buses, tractor-trailer buses, and even aeronautical, since we are so close to Wright-Patterson Field out there.

Of course, in their complaints they want to know what can we do about it as combustion control officials or air pollution control officials and in every case to date we have not been able to do much.

One of the reasons we can't do much is because of the lack of adequate laws. We understand that some cities have proposed laws to control this type of pollutant, but to my knowledge other than Los Angeles probably there has not been anything actually in that regard as far as controlling certain amounts of hydrocarbons being exhausted by motor vehicles.

I would like to quote Dr. Mills just a minute here.

In one of his reports that I read sometime ago it was reported lung cancer rates in every category were sharply increased in Cincinnati men traveling 12,000 miles or more a year in traffic. He felt it was significant. He goes on to say out of 1,900 men and women that they inspected, 531 recent deaths were caused from lung cancer that was attributable to this.

> However much a man smokes, a man who drives 12,000 miles a year or more in heavy traffic is exposed to exhaust fumes that multiply his risk of lung cancer as much as 2 or 3. The rate is doubled for those who live in smoke polluted downtown areas. A heavy smoking taxicab driver who lives there multiplies his danger by many factors and runs a risk of lung cancer 20 to 40 times greater than that of a nonsmoking farmer.

The reason I quote this, it has appeared in some publications and, of course, people in our city read this and they want to know what is being done about it.

It also mentioned here that in the city of Dayton we ran a report on an investigation of exhaust fumes from motor vehicles. Of the buses and trucks that were checked, only 4 percent indicated visually enough effluent to be considered dangerous or that you could say was an air-pollution problem.

But of these, 73 percent of them emitted odors that the investigators felt were obnoxious and 1 investigator even said it made him sick.

Of course, some of these days these tests were made the barometric pressure was low and that made a very slow diffusion of the fumes.

One thing that has not been mentioned here today that I know of in the effluent is the presence of lead. We had a complaint some time ago about a party that had an allergy to lead going to the doctor, and the doctor told her that the lead poisoning was partly due to the effluent thrown into the atmosphere by vehicles.

When I called him he told me that lead could very easily aggravate a person that was allergic to it. A test in a Pennsylvania city indicated an average of 25 parts per million of carbon monoxide poisoning in the atmosphere at peak traffic periods.

We have had a good bit of a problem in Dayton and I think all over the country from carbon monoxide, but I think most of that has been covered here by these men who know more about the harmful effects of carbon monoxide being emitted as an effluent than I know.

I have submitted to the clerk copies of my testimony here. I do not feel I should read through this unless you wish I do so.

From my standpoint as an official for reducing or controlling air pollution, I believe this bill should be given every effort to be passed.

Thank you.

Mr. LOSER. Thank you, sir.

Mr. Doughty, your statement will be filed and made a part of the record.

Mr. DOUGHTY. Thank you.

(The formal statement presented by Mr. Doughty follows:)

TESTIMONY BY ROSS V. DOUGHTY, COMBUSTION ENGINEER, CITY OF DAYTON, OHIO, ON H. R. 9368

The increasing population trends due to longer life and higher birthrates present many problems. Among them, the problem of air pollution control is increasing with the birth of every child. More food and other essential products demanded by our standard of civilization requires more and more use of motor vehicles for transportation of people, produce, and commodities. This increase in the use of vehicles is estimated to double in the United States and its Territories within the next 20 years. With the increase in the number of motor vehicles, the control of exhaust gases is of prime importance. Leading doctors, engineers, and scientists have found direct relationships between automobile exhaust fumes and cancer, as well as other harmful effects on human beings. A few of the findings reported by these parties are as follows:

Drs. Clarence A. Mills and Marjorie Mills reported that heightened lung cancer rates in every smoking category are further sharply increased for suburban Cincinnati men traveling 12,000 miles or more a year in motor traffic.

The Mills team checked 1,910 men and women and tracked down 531 recent deaths from lung cancer. However, much he smokes, a man who drives 12,000 or more miles a year in heavy traffic is exposed to exhaust fumes that multiply his risk of lung cancer by as much as 2 or 3. And the rate is doubled for those who live in smoke-polluted downtown areas. A heavy-smoking cab driver who lives there multiplies his danger by all these factors and runs a risk of lung cancer 40 to 120 times greater than that of a nonsmoking farmer.

A leading authority on cancer, Dr. W. C. Hueper, reported November 13, 1956, that a great majority of lung cancers, particularly in men, are traceable to environmental factors rather than excessive cigarette smoking. During the past five decades, increasing amounts of industrial air pollutants released by some industries producing cancer-related chemicals, and of exhausts of motor vehicles have been introduced into the atmosphere. Evidence that some of these agents possess cancer-producing properties has been shown in chemical analyses of air pollutants of several metropolitan and industrialized regions.

Dr. Morris B. Jacobs, laboratory director, New York City Department of Air Pollution Control, after a 2-year survey, states that 2.2 million tons of corrosive

sulfuric acid may be formed by the gas poured into the New York atmosphere each year. Coal and fuel oil are the chief villains, but motor vehicles, smoky incinerators, and outdoor trash fires are also contributors.

William G. Christy, consulting engineer, New York City, states: "In many communities damage to individuals in a city having air-pollution problems amounts to $30 to $40 per capita. In New York City this damage and waste amounts to more than $225 million per year. Total cost to all citizens of the United States runs as high as $5 billion annually. The increase in motor-vehicle traffic has added materially to the air-pollution problam. Buses and trucks using diesel engines are the worst offenders."

The bureau of combustion control for Dayton, Ohio, reported on March 12, 1958, that only 4 percent of the tractor-trailer units and buses checked emitted enough visible smoke, as measured by the Ringleman smoke chart, to be classified as air-pollution violators because of smoke density. However, 73 percent of these same units emitted fumes which the investigator considered not only obnoxious, but unhealthy. During the investigating period the barometric pressure was low, resulting in very slow diffusion of the fumes.

The amount of concentrated exhaust fumes will be found within the metropolitan areas of the city. This is caused by many factors:

Climatology.—Many cities are in valleys along rivers.

Prevailing winds.—Wind conditions do not always exist in sufficient quantities to move the stagnate air over cities.

Hydrocarbons and other combustion byproducts of industrial and commercial uses unite with vehicle-exhaust gases and build up over the city. These are reacted upon by sunlight which creates ozone and other dangerous electrochemical mixtures.

The contribution of hydrocarbons and other exhaust gases into the atmosphere by vehicles is caused primarily upon deceleration, is somewhat less upon acceleration, and much less at sustained speeds. As motor vehicles approach cities more rapid acceleration and deceleration occurs, throwing gases containing hydrocarbons, oxides of nitrogen, aldehydes, carbon dioxide, and other gases into the atmosphere. Vehicles in which the engines are in poor mechanical condition result not only in poor operating efficiency but emit considerably more harmful exhaust fumes than properly tuned engines. Los Angeles has already on record several alerts, where industry was ordered to shut down, caused by a dangerous amount of ozone in the atmosphere.

The Air Pollution Control Bureau of Los Angeles estimated that automobile exhausts contribute as much as 1,400 tons of hydrocarbons to the air daily in that county.

Other poisonous substances emitted into the atmosphere by vehicle exhausts include lead and carbon monoxide.

A Dayton doctor being questioned about the effect of lead, in leaded gasoline, exhausted by vehicles stated that the condition of a person who is allergic to lead could very possibly be aggravated by concentration of vehicle exhaust fumes which could occur.

Tests in a large Pennsylvania city showed an average of 25 parts per million of carbon monoxide poison in the atmosphere for peak traffic periods.

Reports on record show that during deceleration, unburned hydrocarbons of from 10 to 20 percent are emitted from vehicles. In addition, approximately 6 percent carbon monoxide is discharged. The amount of carbon monoxide emitted by carbureted engines ranges from 1½ to 12 percent.

It is not necessary to point out the thousands of deaths each year caused by carbon monoxide.

It is recommended that the House of Representatives bill 9368, introduced by Congressman Schenck, be passed for the following reasons:

This bill will stimulate and lend emphasis to the passing of similar laws on the State and municipal level. It will be a major step in the control of vehicular exhaust products to which are attributed or are responsible for eye and nose irritants, cardiac and pulmonary impairments, cancer, and many more poor health conditions.

It would encourage manufacturers to develop more efficient exhaust control devices and have them installed as standard equipment on their vehicles.

Truck, bus, and train terminals would cease to be smog-producing centers. In many cases these terminals are located in the central part of metropolitan areas.

As the control of air pollution is becoming more complex and as the number of vehicles used in commerce will increase, it is necessary for the protection of

the public that rigid steps be taken as soon as possible. The Public Health Service will have published in the Federal Register, standards that can be adopted by other State and local agencies. It is further recommended that legislation be proposed enabling the establishment of a necessary technical enforcement body of which a portion would function as a research council responsible for making additional studies of this problem.

Mr. SCHENCK. Mr. Chairman, Mr. Doughty is recognized as doing an outstanding job in the city of Dayton in this field of air pollution control.

I must say for the city of Dayton that with its wide streets and relatively low buildings it does not have quite the same difficult problems that are true in some of the cities which have narrower streets and high buildings.

Is that true, Mr. Doughty?

Mr. DOUGHTY. That is true, Congressman Schenck. We are very fortunate in that respect, that we have good wind currents in the city of Dayton, the streets are wide, the buildings low, there is no real pocket there such as you would have in some other cities.

Mr. BEAMER. Would the gentleman yield at that point?

Mr. SCHENCK. Yes.

Mr. BEAMER. I would suggest to the committee that the city of Dayton smelled very good to us.

Mr. DOUGHTY. Thank you.

Mr. SCHENCK. Mr. Doughty, do you feel with your background of experience and work in this that the exhaust fumes or gases from internal combusion engines are a significant hazard that ought to be controlled?

Mr. DOUGHTY. Yes; I feel that some type of control should be set up so that the effluent that is emitted by all vehicles can be controlled. From the information that I have and the information presented here today we know that there are a good many hydrocarbons and other harmful exhaust gases that are harmful and should be definitely controlled and reasonably soon because with the increase in transportation and the number of vehicles on the road if this condition is allowed to go on for 10 or 20 more years it might become very, very critical.

We will be fighting for the air we breathe the same as 40 or 50 years ago we were really worried about the water we were drinking.

Mr. SCHENCK. I think the facts, Mr. Doughty, are that we are increasing the number of registered vehicles on the road somewhere in the neighborhood of 3 million a year.

You would feel that controlling the type and quality of exhaust gases is at least as important in automotive construction and design as are many other features of the automobiles?

Mr. DOUGHTY. I feel that it is at least as important, and probably more important in the matter of safety than a lot of other items.

In automobiles we have our safety glass and better brakes and so on, but we also must have not only the parties riding in that vehicle, but the parties on that same street behind that vehicle.

Just last week before I left we had a complaint about one of the parking lots, the neighbor adjacent to this parking lot was complaining that these fumes were causing her and her family sickness. We investigated and we found in discussing with the medical doctor that

while he could not pinpoint entirely the sickness on the exhaust fumes, it could be a contributing factor.

In that lot at peak periods the motors would continue to run and these fumes were drifting more or less into this woman's house.

Mr. SCHENCK. Mr. Chairman, I want to express my appreciation to Mr. Doughty for coming over here from the city of Dayton and to the officials of the city of Dayton for authorizing his visit here to give this testimony which I believe will be very helpful and important.

Mr. LOSER. Mr. Beamer.

Mr. BEAMER. I think it is quite a tribute to our colleague, Congressman Schneck, that Dayton, his own home city, is represented here.

Jokingly I made this remark when he yielded to me.

Seriously, when our committee visited Dayton we were very much impressed with the width of the streets, the neat appearance of the city, and also the vigilance that the people have shown in traffic safety.

Mr. LOSER. Thank you so much, Mr. Doughty, for your appearance here and for your contribution to this hearing.

Mr. DOUGHTY. Thank you.

Mr. LOSER. Is Mr. Francis Silver here?

Mr. SILVER. Yes, sir.

Mr. LOSER. Will you come around, please, sir?

Mr. Silver is a chemical engineer from Martinsburg, W. Va.

I believe you have a prepared statement, do you not, sir.

Mr. SILVER. Yes, sir.

STATEMENT OF FRANCIS SILVER, CHEMICAL ENGINEER, MARTINSBURG, W. VA.

Mr. LOSER. I take it that you will make an oral statement in addition to filing the prepared statement?

Mr. SILVER. Yes.

As we go through it I want to refer to a couple of tables in this statement.

Mr. LOSER. You may proceed.

First, Mr. Silver, you are a chemical engineer and are you employed by some governmental agency, or some corporation?

Mr. SILVER. Not now, sir. For about 6 years I was in aircraft weight engineering. I have this background in gas engineering, and I came to realize that this air pollution problem had gotten so serious that I quit my work and have been doing some independent research and writing on that problem.

Mr. LOSER. Go right ahead, sir.

Mr. SILVER. I as speaking as a private citizen, and I have only the interest of other citizens and myself, my family, to consider.

Mr. LOSER. We are happy to have you here.

Mr. SILVER. Thank you.

I graduated in gas engineering from Johns Hopkins in 1937 and practiced combustion engineering for about 5 years after that. I instructed in war gases in civil defense and in the army.

I am a registered chemical engineer, and I belong to a number of professional societies.

I propose to speak on two general topics. First, to look rather broadly at air pollution and how it affects the citizen, and the country, the state of the art, and the urgent need for control measures.

And, secondly, to examine the provisions of this bill as suitable means for dealing with the situation or part of it, and to make suggestions how the bill may be made more effective.

I would like to add orally—the question was raised by Mr. Bush a number of times—Were there methods of dealing with this problem?

As an engineer I feel that there are and that much of this problem has come about because of neglect of consideration of the air pollution features in design of an automobile. The model A car and model T car are examples of vehicles that give out much less air contamination than present cars.

In aircraft engineering every once in a while some design feature will be neglected. I had experiences in my work where a million dollars would be spent on an airplane and the weight aspect of it would not be given enough emphasis and the airplane would not be suitable and the Army could not use the airplane because some design feature was not given sufficient consideration.

Now, this is what has happened in the automobile. For the last number of years air pollution has been neglected. Other factors have been considered more.

A lot of the problems come from the large automobile. So without waiting for any nebulous gadget or focusing all our attention on some gadget that maybe will come in a few years, or 10 or 15 years, or 1 or 2 years, or maybe never, we already have 1 method of dealing with it and that would be a smaller car or back to something that we ought to have.

Now there are other ways of dealing with it, too, with known technological knowledge. It is a matter of balancing equities in design just as in law they speak of balancing equities in lawsuits.

If the health situations are important enough there are available technical methods for solving them.

For that reason the first part of my paper has been confined to the health aspects and to the peculiar nature of toxic gases.

This factor has been neglected in air pollution work, in industrial hygiene work, and that is the reason I, as a gas engineer, who was trained in this particularly, want to bring this in. On page 2 I will read a few sentences I have here.

Wherever men must enter or live in confined spaces such as storage tanks, vehicles, airplanes, tight houses, fully air-conditioned buildings, ships, and especially the submarine, the purity of the air may be vital.

More recently, in large centers of population even the main mass of the air has at times become fatally toxic.

Many types of engineers do not get extensive training in toxicology of gases. However, gas engineers have always needed such instruction. In our collegiate training as gas engineers it was assumed that our duties would require us to take part in, or to direct the work of, opening and entry of gas holders and gas cleaning, scrubbing, and manufacturing equipment.

In order to fit us properly for this kind of work we were instructed very carefully in the behavior of gases generally, and their effect on the human body.

Dr. Huff, our professor, had long been active in the American Gas Association and at the Bureau of Mines and had the benefit of the long experience of these two groups. Several salient features of toxic action on the body were stressed in our training:

(*a*) Most gases acted in whole or in part to reduce the amount of oxygen available to the body cells.

(*b*) The higher nervous centers of the brain were most vulnerable to oxygen lack of any tissue in the body. The other bodily tissue was less damaged by oxygen lack and repaired itself more than nervous tissue.

(*c*) With nervous system damage there would probably be impairment of judgment, although the person themselves may not be aware of this, even right up to the point of passing out.

(*d*) Smell was a poor indicator of toxic levels. Often low concentrations of a gas might smell quite strongly, or sometimes not at all. The sense of smell would dull very quickly. The second sniff often seemed much weaker than the first although the concentration had not changed. In a few minutes the odor might disappear entirely, although the concentration had actually increased. Some toxic gases such as carbon monoxide are odorless to most people and so would give no smell warning at all.

(*e*) If we encountered an odor, rather than enduring it without question, we should attempt to determine its origin and nature. If we were lucky enough to get any warning at all, we should not dismiss it and expect to be forced out of the area by increasing odor or irritation. So many people have already died trying this that it seems foolish for anybody else to try it.

Generally, that gave us an approach to gases. Because the nature of the damage, subtlety of the action, if we got any warning we should act promptly.

Now, this point of view is a little stern perhaps for community air pollution work. I have tried it on a few industrial engineers and they would throw up their hands, "Oh, I could not look at it that way. I would go crazy because there are so many things around that would affect me."

However, if we depart from that kind of strict approach we should do it with caution because of the things I have just mentioned.

Now, if you turn over to page 4 there are some tables taken from the literature which show the variation in the survival time of the various tissues. It shows here that if a nerve tissue is completely deprived of blood—actually that is a little misleading. If you read the original quotation it would be worse than it shows it here—that the cerebrum, the small pyramidal cells, that is the front cortical area of the brain, would only survive 8 minutes without blood, whereas the Purkinge cells, 13 minutes.

The medullary centers 20 to 30 minutes.

Spinal cord, 45 to 60 minutes.

Sympathetic ganglia, 60 minutes.

And myenteric plexus, 180 minutes or 3 hours.

Now, to quote from Dr. Drinker, on page 5:

Such a tabulation readily explains how it is that individuals very severely poisoned by carbon monoxide may be practically decerbrated. Cases of this sort are not infrequent, and the victim may be kept alive for as long as a week

without giving the slightest evidence of ability to receive sensory stimuli or to perform motor acts other than those of the most vegetative type.

Then there is a second table by some other experimenters. So much emphasis is being put on the heart and respiratory damage. It is important, but this table will show that the heart and respiratory damage, at least as far as the nervous aspects are concerned, occur much later than cortical damage.

The table shows that interruption of central circulation of 1 to 5 minutes can be withstood by the cortex. After that, it starts not to function.

The heart and respiratory system can stand up to 15 or 30 minutes before they cease functioning.

There are a number of other references, and ancient ones, clear back to 1909—one of these I mention here is 1913—this is of ancient knowledge, these are not new findings, but I feel they have been neglected findings in air-pollution work.

There are a number of references that I give about the deceptiveness of smell. The humidity seems to make a lot of difference and part of the reason why irritation seems worse in Los Angeles when the humidity is low is that the humidity makes a difference in how irritating agents will be.

There is a reference given in a paper that shows the American Society of Heating and Ventilating Engineers in their laboratories in Cleveland have done some work on cigarette smoke that highlights this very vividly, and they have some beautiful charts that show with higher humidities there is less irritation.

One of the big things that people overlook on this damage to the nervous system is they feel that as long as a person remains logical, that they are still, shall we say, sane, that they are not psychotic, they are not being damaged in any way.

The literature on insanity, on psychiatry, on psychoanalysis, on psychology, is full of examples of the so-called logical insanity, persons who can sit and talk, perhaps much better than I am able to do here this afternoon, who yet have an insanity of such an intensity to be kept in a mental hospital.

This is not unusual; in fact, this is almost usual.

Here is a quotation on the deceptiveness of smell:

Hydrogen sulphide gas is readily detectable in very small amounts by its characteristic rotten egg odor; in dangerous amounts, however, its presence is detectable only on the first inhalation or two, after which the respiratory centers are paralyzed.

Another quotation:

One of the peculiarities of hydrogen sulfide is that the odor when in dilute form is characteristically obnoxious, but when in concentrated form is practically odorless. When the amount is very small or the vapors are highly diluted the symptoms consist in local irritation of the eyes, nose, and throat, indicated by pain of the conjunctive, dryness, sneezing, and soreness of the mouth and throat and increased secretion of tears, saliva, and mucus.

The odor of higher concentration does not become more intense, and above about 200 parts per million the disagreeable odor appears less intense. These perceptions are based upon initial inhalations, and with continuous inhalation the olfactory sense fatigues rapidly.

I am aware of the danger of alarming the population with too strict an interpretation. It is dangerous because the anxiety created in a population can often do more damage than the air pollutant.

It is a thing that has to be handled cautiously.

On the other hand some time or other we have to look at the situation as it is. I feel that these people here and technically qualified people are the ones to look at it.

I have had many experiences where technically trained personnel such as engineers, chemists, firemen, miners, doctors, and nurses who have enough background to recognize the danger, when they are in the grip of a chronic poisoning condition frequently refuse to help correct the condition.

Often they will use their technical knowledge and authority in actively opposing having the condition corrected.

Now, this is a very great danger. I have encountered people in university circles and people in air pollution research work who in their own environment had what I regarded as a serious toxic condition and they had been staying in there for quite a while and I feel to their health detriment, but they had become accustomed to it and did not realize that they should correct it.

Mr. LOSER. Mr. Silver, do you think that you could conclude in 5 minutes with your oral statement?

Mr. SILVER. Yes, sir.

Mr. LOSER. We have a witness from California who wants to go back tonight. The committee would appreciate it if you would do that.

Mr. SILVER. Very good.

I will just turn to the tables in here. I would like to make one quotation from Dr. Warburg. This question of cancer has been raised here.

Dr. Warburg is probably the outstanding researcher on cancer in the world. He is in Berlin with the Cell Physiology Center over there. He has this to say:

> Cancer cells originate from normal body cells in two phases. The first phase is the irreversible injuring of respiration. Just as there are many remote causes of plague, heat, insects, rats, but only one common cause, the plague bacillus, there are a great many remote causes of cancer—tar, rays, arsenic, pressure, urethane—but there is only one common cause into which all other causes of cancer merge, the irreversible injury of respiration.
>
> To the thousands of quantitative experiments on which these results are based, I should like to add, as a further argument, the fact that there is no alternative today. If the explanation of a vital process is its reduction to physics and chemistry, there is no other explanation for the origin of cancer cells, either special or general. From this point of view, mutation and carcinogenic agent are not alternatives, but empty words, unless metabolically specified. Even more harmful in the struggle against cancer can be the continual discovery of miscellaneous cancer agents and cancer viruses, which, by obscuring the underlying phenomena, may hinder necessary preventative measures and thereby become responsible for cancer cases.

On page 20 there is a chart which shows the harmonic land or band of living. This is drawn from many sources. It is my own idea of it. The band which could be an ecstatic or spiritual band is increasingly dominated by the central nervous system.

From Dr. Warburg's concept of cell respiration or fermentation, it would be energy increasingly produced by respiration.

If you look on the right side serenity and radiance are the characteristics of this band.

On the next band, contentment or zest, depending on whether the person is logical or normal.

On the neurotic band, indifference and impatience.

In the psychotic band, apathy and frenzy.

In the comatose band, coma and convulsion.

The question with chronic air pollution is not so much life or death. More important is the question of a high level of living or a low level of living.

In the second part over on page 23 I start discussing the specific provisions of the bill.

Mr. LOSER. Mr. Silver, you need not go into that. We have your statement here and it will be filed.

We want to thank you very much for your contribution to this hearing.

Mr. SILVER. Very good.

(Mr. Silver's prepared statement follows:)

STATEMENT OF FRANCIS SILVER REGARDING H. R. 9368

I am speaking on my own behalf as a citizen of the United States. The only interests that I have to consider in my statement are those of the health and welfare of myself, family, friends, and citizens generally. I do not represent any economic interest in this matter.

My place of residence is 501 South Queen Street, Martinsburg, W. Va.

My technical qualifications are as follows:

Bachelor of engineering in gas engineering, Johns Hopkins University, 1937.

Course in aerodynamics, University of Maryland, 1955–56.

Advanced training, Taft Sanitary Engineering Center, 1958.

Active in combustion engineering for about 5 years.

Instructed in war gases in civil defense and in the Army.

Am currently preparing a paper on air-pollution problems for the American Society of Mechanical Engineers.

Registered professional chemical engineer (West Virginia) since 1942.

Hold membership in the following technical organizations: American Society of Mechanical Engineers, American Institute of Chemical Engineers, American Chemical Society, Biological Chemistry Division, West Virginia Society of Professional Engineers, American Association for the Advancement of Science.

Technical publication: Storage and Handling of Pulverized Material; Mechanical Engineering, September 1951; Mechanical Engineering, March 1952; A Teaching Trick for General Semantics; General Semantics Bulletins, Nos. 6 and 7; spring and summer 1951, pages 89–90.

I propose to speak on two general topics. First, to look rather broadly at air pollution, how it affects the citizen and the country, the state of the art, and the urgent need for control measures. Second, to examine the provisions of this bill as suitable means for dealing with the situation or part of it, and to make suggestions how the bill may be made more effective.

I. (a) General principles in handling toxic gases

Whenever men must enter or live in confined spaces such as storage tanks, vehicles, airplanes, tight houses, fully air-conditioned buildings, ships, and especially the submarine, the purity of the air may be vital. More recently, in large centers of population even the main mass of the air has at times become fatally toxic.

Many types of engineers do not get extensive training in toxicology of gases. However, gas engineers have always needed such instruction. In our collegiate training as gas engineers it was assumed that our duties would require us to take part in, or to direct the work of, opening and entry of gas holders and gas cleaning, scrubbing, and manufacturing equipment. In order to fit us properly for this kind of work we were instructed very carefully in the behavior of gases generally, and their effect on the human body. Dr. Huff, our professor, had long been active in the American Gas Association and at the Bureau of Mines and had the benefit of the long experience of these two groups. Several salient features of toxic action on the body were stressed in our training:

(A) Most gases acted in whole or in part to reduce the amount of oxygen available to the body cells.

(B) The higher nervous centers of the brain were most vulnerable to oxygen lack of any tissue in the body. The other bodily tissue was less damaged by oxygen lack and repaired itself more easily than nervous tissue..

(C) With nervous system damage there would probably be impairment of judgment, although the persons themselves may not be aware of this, even right up to the point of passing out.

(D) Smell was a poor indicator of toxic levels. Often low concentrations of a gas might smell quite strongly, or sometimes not at all. The sense of smell would dull very quickly. The second sniff often seemed much weaker than the first although the concentration had not changed. In a few minutes the odor might disappear entirely, although the concentration had actually increased. Some toxic gases such as carbon monoxide are odorless to most people and so would give no smell warning at all.

(E) If we encountered an odor, rather than enduring it without question, we should attempt to determine its origin and nature. If we were lucky enough to get any warning at all, we should not dismiss it and expect to be forced out of the area by increasing odor or irritation. So many people have already died trying this that it seems foolish for anybody else to try it.

In summary, because of the nature of the damage, because of the subtlety of the action of gases, and because of the impairment of judgment we should act promptly on the basis of our best technical knowledge. There are probably few other human activities where chance taking is less rewarding than in handling toxic gases.

I have been rather perturbed by the tendency of current air-pollution literature to stress gross physical damage to organs of the body such as heart, lungs, liver, and kindneys. Although death and gross physical damage to these organs are useful indicators of how severe a toxic incident in a city was, they tend to obscure the nature and the extent of nervous system damage and glandular imbalance in the population. I would like to introduce some illustrations from the literature at this point. These should clarify the previous numbered rules and give this committee a better basis for deciding whether or not my concern is justified.

The following two tables will show more definitely the relative sensitivity to damage of various nervous tissues in oxygen deficiency. In general, the more differentiated cells are damaged first. (See references Nos. (1), (2), and (3) at end of statement.)

TABLE 1

"The following tabulation compiled from the literature cited by Cannon (1913) and from his own work, shows the survival time of different nerve tissues when completely deprived of blood:

Tissue:	*Survival time in minutes*
Cerebrum, small pyramidal cells	8
Cerebrum, Purkinje's cells	13
Medullary centers	20–30
Spinal cord	45–60
Sympathetic ganglia	60
Myenteric (intestinal) plexus	180

"Such a tabulation readily explains how it is that individuals very severely poisoned by carbon monoxide may be practically decerebrated. Cases of this sort are not infrequent, and the victim may be kept alive for as long as a week without giving the slightest evidence of ability to receive sensory stimuli or to perform motor acts other than those of the most vegetative type. Heymans, et al. (1937) have secured data of much the same sort in experiments in which the circulation to the brain of a dog was completely interrupted for varying periods of time, and in which the ability of the centers to revive was carefully followed. Their results appear in table 2."

TABLE 2.—*The ability of centers at various levels of the nervous system to withstand complete interruption of blood supply*[1]

Interruption of central circulation up to—	Cortical	Revival of centers			
		Palpebral pupillary	Cardioregulatory	Vasomotor	Respiratory
1 to 5 minutes	+	+	+	+	+
5 to 10 minutes	−	+	+	+	+
10 to 15 minutes	−	−	+	+	+
15 to 30 minutes	−	−	+	+	+
Over 30	−	−	−	−	−

[1] Tabulation made by Dr. Heymans and presented to author. Data largely contained in Heymans, Bouckaert, Jourdan, Nowak, and Farber (1937). All of these findings as to the destruction of nerve tissue by asphyxia explain why it is that patients poisoned extremely severely with carbon monoxide still have the power to breathe and so may possibly recover if promptly and properly treated.

Some criticism can be made of the use of these two tables in air pollution work as they deal especially with complete absence of blood or complete stoppage of blood. The blood does perform other functions than oxygen supply. The removal of waste products, temperature control, supply of water, nutrients, and hormones are other blood functions However, the supply of oxygen will ordinarily be the most crucial. There is a good deal of justification for regarding these tables as a rough measure of what happens in oxygen deficiency. (4)

Table 2 also indicates that where there is heart or lung sickness or death in a population, from air pollution, there will probably be a much greater amount of damage to the cortical layers of the brain of the whole population. This table also indicates that where heart and respiratory damage is the focus of research and control measures, a very large safety factor should be introduced if the brain is to be safeguarded. We could almost paraphrase the paint slogan, "Save the surface and you save all," to "Save the cortex and you save all."

Several points were brought up earlier about the deceptiveness of smell and irritation as indicators of toxic levels. There are many references in gas and mining engineering and toxicological literature to this. More recently research people of the American Society of Heating and Air-Conditioning Engineers have evaluated some of these variables of smell and irritation more precisely. References (5), (6), (7), (8), and (9) will explain these matters in considerable detail. In summary, odor, and irritation is much less intense at higher humidities. Through much of the range 10 times the concentration doubles the odor intensity, but above a certain intensity some substances become almost odorless. Intensity of smell decreases very rapidly with time. Often the second sniff seems appreciably weaker than the first. Reference (8) shows irritation from cigarette smoke building up with time but their experiments were only run for 6 minutes. My own experience with cigarette smoke, sulfur dioxide, smog, and some other unknown irritants suggests that the buildup of irritation may continue for a long time, perhaps even hours, but if strong enough, eventually ceases suddenly as the mind refuses to monitor the pain any longer. The area of irritation may remain numb then and what is happening to the body is no longer in the consciousness. Many people are proud of their numbness, and their ability to "take it without feeling."

The ability to endure may be a measure of ability to "take it" and of the ability to remain "logical" under stress. Unfortunately it is also a measure of the ability to damage one's body without taking corrective action to stop the damage. Tissue and organism irritability is an important protective mechanism. To suppress "complaining" unduly may be a very indiscreet way of responding to toxic conditions. In mining practice it is continually stressed that all persons should not dismiss the complaints of the most sensitive individuals or animals. Not only should such complaints be respected, they should be looked for and acted upon. The pitfalls of endurance and numbness are too insidious for us to expect to win against them regularly.

A few quotations are in order. From (5), "Hydrogen sulfide gas is readily detectable in very small amounts by its characteristic rotten-egg odor; in dangerous amounts, however, its presence is detectable only on the first inhalation or two, after which the respiratory centers are paralyzed." From (6), "One of the peculiarities of hydrogen sulfide is that the odor when in dilute form

is characteristically obnoxious, but when in concentrated form is practically odorless. When the amount is very small or the vapors are highly diluted the symptoms consist in local irritation of the eyes, nose, and throat, indicated by pain of the conjunctiva, sneezing, dryness, and soreness of the mouth and throat, and increased secretion of tears, saliva, and mucus." From (7), "The odor of higher concentrations does not become more intense, and above about 200 parts per million the disagreeable odor appears less intense. These perceptions are based upon initial inhalations, and with continuous inhalation the olfactory sense fatigues rapidly."

Some criticism can be made of applying the above principles too strictly in community air pollution work. There is always a need for commonsense and understanding. Perhaps in community air pollution work we should hold these principles as an ideal which we would try to approach. We would depart from them with caution because they provide a way of meeting the subtleties of many toxic gases.

There is good reason for not alarming a populace about some threat. The anxiety so created often causes more harm to the organism than the danger itself. It is an old story that the panic at the fire often causes more deaths than the fire. However, we cannot evade these issues forever. This seems like an appropriate place to attempt to determine the truth. My experience is that people do not panic easily in chronic air pollution situations. On the contrary, it is very difficult even to arouse enough interest to correct very serious conditions. The setting in of patterns of enduring the pollutant, rigidity in terms of rejection of new ideas and resistance to change, and impairment of judgment all combine to prevent panic and to make correction difficult where popular arousal is required. Even technically trained personnel, such as engineers, chemists, firemen, miners, doctors, and nurses, who have enough background to recognize the danger, when in the grip of a chronic poisoning condition frequently refuse to help correct the condition. Often they will use their technical knowledge and authority in actively opposing having the condition corrected.

As the manger of our local gas company, who is also a mechanical engineer, expressed it, "Reasonably pure air is going to cost all of us a little money, and perhaps some of us quite a little. And we won't have much to show for it except increased health and happiness and lower mortality and morbidity rates. It is going to cost money for consumers, governmental bodies, taxpayers, and various industries. But we had better get on with it."

There are those who call any activity which does not produce some form of hardware "impractical." These individuals will probably have a field day pointing out the impracticality of air-pollution-control measures and expenditures. I wonder how practical they think it is to have to pay salaries of people whose efficiency is much reduced because of air pollution.

There is enough evidence of the deceptiveness of air pollutants that an attitude of alertness and fairly prompt positive corrective action seems in order. Attitudes of enduring the material until acclimatization results would seem out of order except in carefully controlled experiments.

My more recent experiences and studies of chronic toxic conditions suggest that several other reactions to toxins need to be considered. These other factors are: (F) Hidden damage and its possible later reactivation, (G) accumulated damage, and (H) addiction, tolerance, dependence.

Hidden damage and its possible later reactivation is sometimes mentioned in the literature as not having been proven. There are also many loose statements in the literature regarding toxic episodes that conclude incautiously that the victim had fully recovered, or had no lasting aftereffects. The best available evidence indicates definitely a mechanism of hidden damage. An almost casual examination of the structure and functioning of the sensory nervous system and its relationship to the cerebrum and conscious mind would suggest the presence of some such mechanism. Such damage is not readily apparent or it would not be called hidden. This damage may become important to the health of the individual at any later date. I can cite so many quotations to support this view that incautious statements to the contrary can only be regarded as uninformed or deliberately misleading.

Prof. Otto Warburg, director of the Max Flanck Institute for Cell Physiology, one of the most respected figures in the microbiological field, made this statement in his classic summary of his long work (Science, Feb. 24, 1956, p. 310) (10):

"The mysterious latency period of the production of cancer is, therefore, nothing more than the time in which the fermentation increases after a damaging of respiration. This time differs in various animals; it is especially long in man and here often amounts to several decades, as can be determined in the cases in which the time of respiratory damage is known, for example, in arsenic cancer and irradiation cancer."

References (1), (11), (12) cite cases where the victims of toxic episodes had apparently fully recovered, and then sickened or died hours to weeks later. References (13), (14) present hidden damage and its later importance to the individual as cases or as well known. (19)

In irritation and poisoning generally, the most important thing is not accumulated poison, but accumulated damage.

Addiction to and dependence on harmful substances are easily observable in our society. My personal experiences with air pollutants indicates that this is one of the mechanisms which blocks control measures. Dr. Warburg's paper (10) suggests part of the possible mechanism acting in addiction. Behavior similar to that of horses running back into a burning barn has been observed in humans and is reported in mining and fire-fighting literature. (15, 16)

Of interest also are references that show that the psychotic can withstand 2 to 6 times as much poison as the normal. It appears that the body may adapt itself to poison by "going psychotic." (17, 18) Both toxicological and psychiatric observers have for years reported the similarity between the symptoms of toxicity and insanity. (21) Other references show a positive correlation of sensitivity with intelligence. (20) I am aware of the need for a doctor to be reassuring to a patient about "aftereffects," and of the desire of individuals and companies to protect themselves against suit. However, we do not expect what is done for reassurance to always be factual.

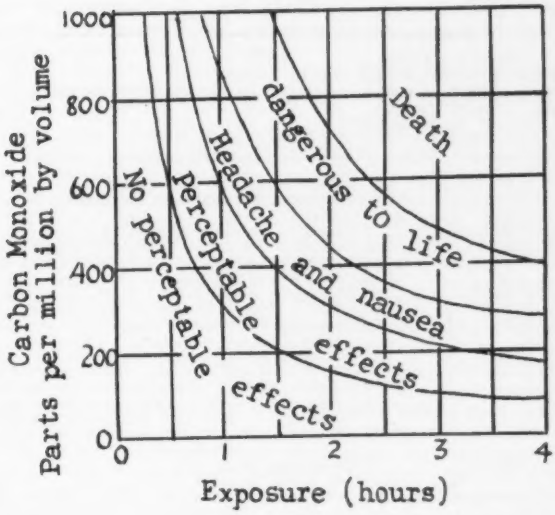
As a summary to this part of my statement I will quote from Dr. Warburg's article:

"Cancer cells originate from normal body cells in two phases. The first phase is the irreversible injuring of respiration. Just as there are many remote causes of plague—heat, insects, rats—but only one common cause, the plague bacillus, there are a great many remote causes of cancer—tar, rays, arsenic, pressure, urethane—but there is only one common cause into which all other causes of cancer merge, the irreversible injuring of respiration."

"To the thousands of quantitative experiments on which these results are based, I should like to add, as a further argument, the fact that there is no alternative today. If the explanation of a vital process is its reduction to physics and chemistry, there is no other explanation for the origin of cancer cells, either special or general. From this point of view, mutation and carcinogenic agent are not alternatives but empty words, unless metabolically specified. Even more harmful in the struggle against cancer can be the continual discovery of miscellaneous cancer agents and cancer viruses, which, by obscuring the underlying phenomena, may hinder necessary preventive measures and thereby become responsible for cancer cases."

I. (b) On setting toxic limits

I have been increasingly concerned as I have studied in detail the basis for some of the maximum allowable concentrations for 8 hours' identical exposure. Carbon monoxide is one of the simplest acting and most thoroughly studied of any of the toxic gases. There may be persons present who are not aware of the fact that in air-pollution damage time of exposure is nearly as important a factor as concentration. This can be represented roughly by the equation: concentration$\times$time=damage. For carbon monoxide, this can be shown on a graph. (29)



If one has a chart such as this and he knows what the gas is and what is the time of exposure, an estimate of the concentration can be made from the symptoms observed in other people, or in one's self. This is a standard method of analysis called bioassay, and if set up formally, using plants or animals with proper controls, can give very good quantitative results. Many vitamins and similar products in commerce are regularly standardized in this fashion. The requirements for human nutrition must eventually be arrived at by bioassay on human subjects (22). Similarly, toxic effects on humans must eventually be related to human reactions. Usually, taxic effects on humans are not set up as formal experiments, but are arrived at by some type of informal bioassay, by extrapolation from serious toxic accidents where some estimate of the probable exposure is available, or by extrapolation from animal experiments with an animal which is thought to respond similarly to man to the substance in question. Occasionally some brave soul or some ardent seeker after truth will use his own body in such experiments. We are deeply indebted to men like Prof. J. S. Haldane and Smith Griswold for formal toxicity experiments on their own bodies reported in the literature. (15), (24), (25)

Considering the present limitations on chemical and instrumental methods and on formal experiments with humans, the informal bioassay still has as much place in air-pollution work as it did in the old days of the "sniffer" who went around looking for gas leaks. I have made a specialty of this myself; it enables me to walk through a city or plant and in a few hours get some idea of the toxic levels by carefully observing my own reactions and closely scrutinizing the people I pass. It has the advantage of simplicity and directness, and that unknown synergistic effects and unknown toxicities are automatically allowed for, giving an index of actual total toxicity. It has many weaknesses. The level of the various components is uncertain, and their change in level is uncertain. Its biggest disadvantage is that the findings are so highly subjective that they are difficult to present to others. Persons who specialize in selling, in interviewing, some managers and teachers, the so-called sensitive, and many workers in medical, legal, and psychological fields are often very skilled in making the necessary type of observation on others, but they are usually not trained in relating their observations to toxic exposure.

Some idea of the variance in possible standards that might be suggested for carbon monoxide can be obtained from this listing:

TABLE 3

Approximate blood saturations (from chart) (26) p. 179	Parts per million by volume of carbon monoxide in breathed air (long exposure)	Basis for standard
1 or 2 percent	5 or 10	Easily measurable impairment in human dim light vision obtained by combining information from 2 references (26) (28).
4 percent	20	Suggested maximum allowable for mines (27).
6 percent	30	Suggested maximum allowable concentration for aircraft (includes allowance for altitude and carbon monoxide detector limitations) (26) (29).
12 percent	50	McFarland states that this is the generally agreed upon maximum allowable concentration for long exposure but says it is too high for an active person (29). Used in Italy and some other European countries.
17 percent	100	Maximum allowable concentration for 8-hour exposure as set by American Conference of Governmental Industrial Hygienists (30). This was at one time lowered to 50 but was raised to 100 again because the blood saturation of chain smokers is often this high. Acute symptoms of carbon monoxide poisoning present at this blood level (26). Los Angeles 1st alert (35) (23).
29 percent	200	Los Angeles 2d alert.
38 percent	300	Los Angeles 3d alert.
	3,000	In experiments, mice and rabbits could be gradually adapted to live in this level. Both could grow. Mice were not fertile. No fertility tests on rabbits (1) (p. 137).

If the hundred parts per million were used with a generous safety factor (say 5 or 10) as is quite usual in engineering work and as is suggested in Bureau of Mines publications (31) and in the American Society of Heating and Air-Conditioning Engineers Guide (32) it would seem like a reasonable figure. However, I find many industrial-hygiene and air-pollution people who regard these figures as safe upper limits without using a safety factor. There are many warnings in the literature not to do this but it is still being done.

In examining the basis for the 100 parts per million for CO we find the following statement: "In the United States chronic poisoning is not considered a reality. The 100 parts per million can be interpreted from the results of extensive human experiment and examination of exposed workmen. It will prevent injury, but will allow a recognizable effect if inhaled for 8 hours" (American Industrial Hygiene Quarterly, June 1956, vol. 17, p. 149). (37)

One of the reports which is used most heavily in justifying the 100 parts per million is the study of policemen who had worked in the Holland Tunnel for 13 years. According to the report in the Journal of the American Medical Association (vol. 118, 1942, p. 585), the men's exposure averaged only 70 parts per million and their tunnel work consisted of only 2.2-hour exposures or a total of 4 hours with a 2-hour fresh-air interval in the middle.

Ozone seems to be one of the more important secondary results of vehicular exhaust. Until 1954, the industrial hygiene level for ozone was 1 part per million. In 1954 it was reduced to 0.1 part million or by a factor of 10. The 1950 guide mentioned above has this to say about ozone (p. 17):

"Ozone in amounts of 0.01 to 0.05 per million of air is allowable in comfortable air conditioning. Above this limit there is a pungent, unpleasant odor and perhaps respiratory distress, depression, and stupor."

And on page 157 states, "The values finally adopted will undoubtedly be lower for community air pollution work than the MAC (maximum allowable concentration) limits for use in industry because the exposure is continuous compared with the 8-hour day, 5- or 6-day week upon which the MAC values are based, and because the exposed population contains individuals with greater variation in age and health status."

Griswold was exposed to 2 parts per million for 2 hours and his system was seriously shocked and noticeable effects remained for 2 weeks afterward. It would probably require quite a bit of depth psychology to determine exactly how much buried trauma still remained.

In Los Angeles, ozone levels have been at 0.90 part per million for 30 minutes, above 0.70 part per million for 1 hour and 30 minutes, and above 0.50 for nearly

3 hours on September 13, 1955. (33, 23) Speculating on the effects of other contaminants, we could guess that the entire population may have received a toxic dose approaching what Griswold received.

Reference (36) states, "Ozone concentrations on Staten Island and in Carteret, N. J., are exceeded only by those for Los Angeles, San Francisco, and Silver Spring, Md."

Reference (37) gives this as the basis for the 0.1 part per million MAC level for industrial hygiene work, "Fairhall (1949, p. 122) quotes McDonnell's incompletely reported work to the effect that daily inhalation of 0.1 part per million killed guinea pigs with pneumonia, higher concentrations leading to lung edema. He notes respiratory tract irritation with fatal pneumonitis or lung edema, but no systemic poisoning. He quotes a statement that 0.015 part per million can be smelled and any higher concentration is irritating.

"The most important effect of ozone inhalation is respiratory tract irritation, with lung edema the maximum effect. The 0.1 part per million threshold limit can be interpreted from results of limited repeated animal inhalations and human sensory data. It appears low enough to prevent injury."

The problem of relating degree of damage to the human organism with certain concentrations and durations of toxic gases and fumes, such as unburned hydrocarbons is fairly difficult with even a single toxic substance. There are wide variations observable and disagreement in the literature about even so simple acting a substance as carbon monoxide. Most other substances are more complex in their action and are less well understood. Often the amounts required to be physiologically significant are so small that our method for measuring them leave much to be desired. Only recently have we ever started to get a good idea of what some of the important substances were. The accuracy of getting a sample that will represent what the average citizen in a community will encounter is very uncertain to put it mildly. It seems now that the toxic effect from the presence of several different substances is usually additive. However, it seems that, in a small percentage of cases, substances may either neutralize or magnify each other's actions. This latter action is commonly called synergy or synergistic action. There are indications that in a few cases this can be very high. Apparently dusts, gases, and vapors can all act synergistically.

Probably after many years experience, through morbidity and mortality studies, we will learn to relate certain measurements on our instruments with certain levels of population damage. This relationship will probably be an indirect one, and will have hidden in it many bits of ignorance involving weaknesses in measurement and sampling of both substances and illnesses.

I have had occasion to participate in the operation of several different chemical plants where control was maintained by indirect or time-delayed measurements. Although rather difficult to control it at first, eventually personnel would get the feel of it and learn how to regulate the process. I think this is called flying by the seat of one's pants in aircraft parlance. However, occasionally something unknown would occur, and it would often take several days to a week to get things back in line. In some of these processes we had both upper and lower limits for certain chemical constituents, and in others just upper or lower limits. The matter of air pollution control has some similarity to the operation of certain chemical plants. Usually, however, there will only be upper limits on toxic elements, which is about the only note of simplification. My experience in control in chemical plants suggests that, unless we are prepared to accept crude mass experimentation on human subjects, we should use a very large safety factor in control work.

Warnings accompanying the table of maximum allowable concentrations for industrial hygiene use state that they shall not be used in community air-pollution work, and these warnings seem well justified. However, there is not much else to use at present, so I suspect they are relied on rather heavily. Speculations have been made that if a safety factor of from 4 to 20 were applied, these figures would have validity for communities. I have only studied a few of these figures in detail, but those seem to be on the borderline of definitely perceptible effects, and thus should be regarded as truly maximums, and as not including a safety factor for long continued exposure even in industrial hygiene work. They are for the presence of one item only. Perhaps, considering the variables involved, it might be well to lean toward the higher safety factor; at least until we know more about the field.

I find many of our industrial-hygiene and air-pollution people are intrigued by the ability of the human body to adapt to toxic substances. We must ask,

however, What is the nature of the adaptation? Will large sacrifices in terms of productive and enjoyable living have to be made to adapt to a given toxic level?

It is now common knowledge that insects adapt to DDT after some years. The adaptation of these insects took many generations in which most of each generation was killed. I have no data on whether the bugs are happy or not. But I must confess to some uneasiness when I hear toxicologists speculate that they think maybe the gene pool of a human population is much less variable than the gene pool of an insect population, perhaps by a factor of 10. The variability of the gene pool of a population is a useful way of expressing ease of adaptation over several generations. Thinking in such terms is necessary, and even lawmakers may wish to consider such studies. But I feel that what happens to this generation, and what happens to people as individuals, rather than as populations, may be of even more importance in making laws.

In our own thinking when setting allowable toxic limits we should not lose sight of the fact that bubbling, vigorous good health, both mental and physical, should be regarded as desirable and normal. We should not gear our health programs to grim, bare survival. The fact that many persons are condemned by circumstances to a drab and colorless or else obsessional existence is not sufficient reason to accept this as a standard. Toxicological and medical workers in setting standards should realize that they and their family and friends will be affected too. Where economic necessity or engineering difficulties occasion the setting of a higher standard than would otherwise be desirable, these factors should be clearly stated, and not buried under rationalizations about physiology. We are all in this thing together.

The following oversimplified table may help give a clearer view of the various levels of living. Toxicology and pharmacology are such complex subjects that we need a guidepost.

TABLE 4

Functioning of nervous system and mode of cellular energy production (10)	Harmonic or band of living	"Tension"	Approach to life	
			Detached	Active
Behavior increasingly dominated by central nervous system; energy increasingly produced by respiration.	Ecstatic or spiritual	Relaxed, poised	Serenity	Radiance.
	Logical or "normal"	Relaxed, balanced	Contentment	Zest.
	Neurotic	Tension, complaints, aches and pains with little very seriously wrong.	Indifference	Impatience.
	Psychotic	May be limp or numb or agitated. Apparently good bodily health; if anything does go wrong, very hard to fix.	Apathy	Frenzy.
Increasing dominance of involuntary nervous system; energy increasingly produced by fermentation.	Comatose	May be either limp or spastic.	Coma	Convulsion.

The Congress may wish to specify that the standards should be such as to permit a high level of living. Otherwise as the population grows and air pollution becomes increasingly important, we may find the majority of people condemned to live in the bottom bands by insanitary air. I read so many articles deploring the disappearance of the oldtime virtues of integrity, courage, happiness, interest, purpose, leadership, and serenity that I suspect perhaps we have gone right far along that road already. Moral fiber may be closely related to nerve fiber. The tensions of modern civilization may originate more from toxicity than hurry.

Since there are bands free of tension both below and above the band of tension, reactions may be very deceptive. This may explain in part how a person who has been in an atmosphere containing carbon monoxide may experience headache after being in fresh air for a while. It may also explain one of the mechanisms

of release from tension by alcohol and smoking. If an individual were in the lower part of a band of tension almost any substance that has a toxic effect on the body might give release from tension. Griswold stated that at the end of his ordeal he felt like he had drunk six martinis. (24) Armstrong gives examples (26) of pleasant feelings and euphoria with anoxia, in some cases so severe that the individuals were blind and paralyzed. The present high level of acceptance of the toxic or numbing solution to neurotic problems by both medical and lay people beclouds an already deceptive picture. The issue is not made clearer by hypnotic sales pressure for depressant substances. (38)

The previously quoted statement from the Industrial Hygiene Quarterly reflects the thinking of many industrial hygiene people. ("In the United States chronic poisoning is not considered a reality.") Other statements, that there is no such thing as "hidden damage," and, rather loose comments, that the person "fully recovered" after having been gassed, are greatly at variance with the findings of some of the most respected workers in the field. When I have bombarded some of my friends in the industrial hygiene work with questions about this, several of them replied that I did not understand the industrial hygiene position. They said that many industrial hygienists were genuinely interested in the worker and did their best for him, but they were employed to safeguard the company and not the worker, and that I would have to understand this viewpoint if I wanted to understand industrial hygiene.

Another time I was commenting to a toxicologist that if I traced the quotations back through the literature to the original document, I often got a very different picture. He commented that he found it rather alarming himself to realize that the fate of many people might be determined by what happened to one mouse 20 or 30 years ago, and added that an experiment is often copied and recopied in the literature until it acquires the weight of great authority.

In summary, toxic limits are both controversial and arbitrary. The way in which they are arrived at must be available for them to be applied intelligently and to avoid the defects of a hidden standard. They should be geared to a high level of living and not to a drab existence. They should embrace the best available evidence from both biological and psychological fields. They should be responsive to new understanding. Since toxic effects are so often nonspecific, nonspecific tests should play an important role in establishing them. The doctrine of balancing the equities should be recognized, but it should also be recognized that to the individual concerned, the difference between good health and happiness, and poor health and unhappiness, is often as great as the difference between life and death. It is difficult to place economic value on such things but they would ordinarily be very high.

II. Examination of specific provisions of H. R. 9368

There are several difficulties peculiar to an air pollution control measure, principally:

(1) Toxic levels in the free air are only indirectly related to any one source of contamination in most cases. Toxic levels may be the result of a summation of several million sources such as the large number of homes, automobiles, and industries in a large city. Terrain and spatial relationships may be as important factors as concentration at point of emission.

(2) Meteorological conditions may be as important as any other factors. These vary with time in an uncertain fashion. The nature of the relationship of man and toxicants forces us to design control measures around the worst possible conditions. This means we can be accused of "overcontrolling" most of the time.

(3) The lives and health and economic interest of many people and groups are affected in many ways by control efforts or lack of them.

(4) The relationship of the variables is such that any limit set on a particular source or group of sources will usually be arbitrary to a high degree. There will always be a considerable basis for charges of bias and unfairness, especially with individuals who are unfamiliar with or refuse to look at the broad picture.

The difficulty of making air pollution control decisions in no wise relieves us of the necessity for making these decisions. In all phases of air pollution control work we will almost always be in the position of making forced decisions.

There is much to be said for exerting air pollution control efforts in a manner which will permit the individual or group that is making sincere efforts to correct their condition a reasonable indulgence.

There is little to be said for letting any individual or group or number of groups continue to ignore their responsibility for their part in contaminating the air.

In short, we are forced to act now on the basis of the best available evidence. It would seem to me that we have already delayed much longer than prudence would dictate. Demands by vested interests that we wait until invariable conclusive scientific proof is at hand should never override acting on the basis of the best available evidence.

A possible formula for application to an area would be—

$$\frac{\text{Proposed acceptable limit in air}}{\text{Present concentration (worst condition)}} = \frac{\text{Allowable discharge per vehicle (average)}}{\text{Present average discharge per vehicle}}$$

Once this figure was established (allowable average discharge per vehicle), as the number of vehicles increased the quantity of fumes per vehicle times its toxic index should decrease proportionately. Such an approach would relate a number of the factors involved in a manner that seems fair.

In addition to technical difficulties, there are considerable administrative difficulties. The majority of air pollution control work will probably always be handled by local agencies which will be responsive to the needs peculiar to a local area. So there will be problems of overlapping and ignored jurisdictions. There is a need for close cooperation.

Several authoritative references suggest that air pollution control measures should be entirely of local or State origin. (39), (40) There are a number of reasons for not confining ourselves to this viewpoint:

(1) In interstate commerce, even when a vehicle is moving along a highway in an unpopulated place where air pollution would not normally be of consequence, there may be a safety hazard to the driver of the vehicle behind, particularly on hills. Most drivers have had some experience of being distressed by the fumes of a truck, bus, and occasionally even a car, coming back from the vehicle in front. The driver will then have less control of his car, and may take chances in passing to get out of the objectionable fumes. Safety on the highway in interstate commerce is a matter of interest to this committee.

(2) Many small communities will not be able to afford adequate technical help to control vehicles passing through. Admittedly the air pollution problems in isolated small communities are not acute ordinarily, but in suburbs it often is acute. In general, fumes from commercial vehicles are significant in the problem of vehicular fumes on sidewalks and adjoining buildings.

(3) Objections to Federal regulation of air pollution are often based on infringements of individual liberty. I am not an advocate of excessive regulation either, but we are developing air pollution situations that severely restrict the freedom of motion of the individual. If each local area permits a different level and different composition of pollution to develop, we may find that we cannot go to certain other cities without extreme risk to our health and even life. It is my opinion that we have already reached this point to some degree. Also, the matter of dependence on a normally toxic substance may intrude in such a way that the individual could not leave his local area without encountering a very difficult adjustment. This peculiarity alone would be a basis for a certain amount of guidance and supervision at the Federal level. Already it has been found necessary to set up multistate boards for control of water pollution, usually along a certain watershed. Similarly interstate air pollution commissions for handling the problems peculiar to air drainage and population areas appear necessary. (36), (41)

(4) Present conflicting regulations of various States and communities regarding commercial vehicles have certainly not pleased the vehicle operators. They often express views that they wish rules about lights, weights, etc., were more uniform over the country.

Section 1 (a) provides that the setting of standards shall be by the Surgeon General of the Public Health Service, and that they shall be published in the Federal Register. A limited time is allowed for necessary research, but this may not be prolonged indefinitely.

This involves a delegation of power by Congress to an administrative individual which I feel is necessary because of the technical and arbitrary nature of the standards and their need for revision from time to time. I think it appropriate that this power be reposed in the hands of an individual mainly concerned with

the health rather than the economic life of the Nation. I feel this way because of the subtle nature of air toxicants. I feel that some time for research is necessary, but that it should be limited; 6 months seems appropriate.

Publication of the standards is a vital part of such an act. In our control work in chemical plants we found a hidden standard to be a hindrance. It is vitally important to an understanding of a published air-pollution standard that the basis by which the standard was arrived at be readily available to all control personnel. If this is not done, even published numerical figures still have so much necessary background missing that there is still a hidden standard. I cannot stress too much the need for ready access by the public to the basic facts and opinions on which a standard is based. Perhaps this bill should state that "the basis in opinion and fact by which the standards are arrived at shall be published in some readily available form and the reference listed in the Federal Register with the standard."

I might suggest adding the word "reasonably" before the word "safe" on line 9. In toxic and health matters safety is rarely either black or white, but a gradient scale of probabilities. Safety is often more a matter of degree than absolutes. The setting of what may prove to be a factually impossible standard weakens rather than strengthens a bill. It is still questionable as to whether or not there is a lower limit on toxic damage. So far engineering and economic considerations have influenced the setting of toxic limits as much as health considerations.

I assume the words "safe from the standpoint of human health" are to be interpreted in line with the World Health Organization definition of health to include mental as well as physical health. It might add clarity to include a definition of this term in the bill, unless it is the intention of the Congress to limit this bill particularly to carcinogens. Heart, circulatory, sensory, respiratory, and nervous system difficulties are of more importance numerically than cancer and may also be caused by air pollutants. The large amount of publicity about lung cancer in relation to smoking has caused it to assume an undue importance in the public eye. Less emphasized has been the effect of smoking on death rate from cancer at other sites and from noncancerous mortality. (42)

As an engineer, I first questioned whether the word "amount" would convey clearly the intent of the Congress. I tried to substitute a number of more specific terms as "rate," "concentration," "volume," in various combinations, but each thing I tried either added other ambiguities or excluded some control measure that might have to be used. So, despite my desire for more specific expression, "amount" seems quite suitable here.

I would suggest the use of the words "incompletely burned hydrocarbons" for "unburned hydrocarbons" so that the term might not be limited to raw fuel, but would apply also to smoke, partially burned hydrocarbons, and carbon monoxide. This appears several times in the bill. I have also wondered why the bill was limited to hydrocarbons, although I realize they are currently in the limelight. A few years ago sulfurdioxide was the big issue, but the emphasis has changed. It would seem to me advisable to make the bill even broader and have it read "air contaminants" where it now reads "unburned hydrocarbons."

For those committee members who may not be familiar with the significance of hydrocarbons, it should be mentioned here that, although they are not always extremely toxic themselves, in the presence of sunlight many reactions take place which produce other substances which are highly toxic. Currently ozone and benzypyrene are receiving a great deal of attention, but the chemistry involved has not been definitely pinned down.

Section 1 (b): I am completely in accord with the need for revision of these standards from time to time, and with the methods suggested for the accomplishment of revision.

Section 2 (a): Section 1 deals with the setting of standards. This section deals with the application of these standards. Suggested changes in terminology for section 1 would carry through into this section.

This section introduces the term "use in commerce" into the body of the bill. It will not affect the majority of vehicles in use in a populated area as these are not used in interstate commerce. To bring the private car under some sort of control will probably require restrictions on manufacturing and marketing, in interstate commerce, a vehicle that is designed to, or will permit the discharge of, excessive amounts of air contaminants. If instead of the word "use," we substitute the words "manufacture and market or use" it would give some control over the private automobile. The best available evidence indicates that this would be necessary to control air pollution to a safe-to-health level.

The manufacturer of vehicles has a definite, although indirect, responsibility to consider air pollution, in the design of a vehicle. The vehicle manufacturer can hardly expect the individual user to make the engine-design studies, or to develop and install the equipment necessary, to reduce the contaminants in the vehicle exhaust.

Fashion and style are variable and related to conditioned reflexes established in the individual. There is evidence that fashion and style considerations have been allowed to dominate automotive design to the detriment of operating economy, ease of maintenance, and air-pollution considerations. (38)

The bill, as stated, seems to cover adequately auxiliary engines, such as are used for air conditioning and refrigeration as well as motive power engines.

Since the intention of this bill is apparently to protect the health of citizens, and since there are very many cases of dangerous toxic conditions inside of commercial vehicles which affect the welfare of passengers I would suggest that a clause be inserted near line 9, page 2, relating to the maintenance of safe-to-health air inside of commercial passenger vehicles. This would probably also increase the patronage of buses and trains and cut down the unnecessary use of private cars. I have personally had many experiences on trains and buses where the air became highly toxic. One type of railway coach is improperly designed, so that fumes from the air-conditioning engine are drawn into the ventilating system. Toxic deodorants are use quite generally in toilets on trains and in stations. My friends give the fumes in trains and buses most often as their reason for not wanting to ride on them.

The type of fuel that is burned may influence the toxicity of the exhaust. This is particularly true of sulfur in fuel oil at present. Control of vehicle exhaust may cover this, or provisions about fuel quality may also be considered.

The remainder of the bill, section 2 (b) and section 3, and section 4 seem to be standard provisions for implementation of such a bill. Except for the addition of a definition of "safe for health" in section 3, as mentioned previously, I have no further suggestions for this part of the bill. I am in accord with the provisions and wording.

In summary, I have attempted to show that there is clearly a need for additional control of air pollution; that this cannot all be relegated to local and State governing bodies; that the Federal Government has a responsibility to protect the health of the Nation in areas where local controls cannot be effective; and that this bill is an appropriate measure in its present form; however, it could be changed slightly so as to be an even more valuable piece of legislation.

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Mr. LOSER. Mr. Griswold.

STATEMENT OF S. SMITH GRISWOLD, AIR POLLUTION CONTROL OFFICER, LOS ANGELES COUNTY, CALIF.

Mr. GRISWOLD. Mr. Chairman, gentlemen of the Congress, it is a pleasure to be here.

My name is Smith Griswold. I am air-pollution-control officer for the county of Los Angeles, and am appearing before your committee today in regard to H. R. 9368. I appear here on instructions of the Los Angeles County Board of Supervisors, which serves also as the air-pollution-control board for all of Los Angeles County.

Mr. Kennedy, whom you heard first this morning, is the legal counsel for the board. I am the administrator of the air-pollution-control district which is an organization of some 420 scientists, engineers, research meteorologists, and is responsibile for carrying out the control program in the county.

On Tuesday, March 11, 1958, the Air Pollution Control Board of Los Angeles County unanimously expressed itself in favor of:

The principles contained in H. R. 9368 regarding the establishment by Federal authorities of permissible hydrocarbon emission standards for motor vehicles.

We feel that three matters should be brought to the attention of your honorable committee:

1. The increasing importance of motor vehicle exhausts to the occurrence of serious community air-pollution problems;
2. The technical, legal, and administrative difficulties complicating the development of adequate solutions to this problem by local jurisdiction of government; and
3. The possible role of Federal agencies in contributing to the solution of the community air-pollution problems throughout the Nation by aiding in the development of acceptable remedies to the specific problems posed by motor-vehicle exhausts.

Los Angeles County has the most notorious air-pollution problem in the Nation. It is also the most expensive.

In our county—

Fifty million dollars has been spent by industry for air pollution control equipment.

Five million dollars is being spent every year to operate that equipment.

Forty-eight million dollars worth of incinerators have been junked.

Twelve million dollars has been spent to acquire cut-and-cover dumps to dispose of the rubbish no longer burned in those incinerators.

Thirty million dollars has been lost in damage to crops and other vegetation.

Ten million dollars has been spent by our county government to control air pollution.

Four million dollars a year must continue to be spent by the county.

Six million dollars has been expended in private research, a cost ultimately passed back to the public; and in addition, $10 million has been expended by the State and Federal Governments.

This is far from the full price tag on air pollution in just 1 county of 1 State. Who can compute the loss in time and efficiency due to air pollution. Who can put a value on the discomfort it has caused? How important are the health effects?

We have done everything that it is within our power to do. We have cleaned up industries that in other sections of the country have been deemed impossible to control—that was covered by a committee in Los Angeles investigating the effects of air pollution on small business, that is, as to whether the employees in small business realized fully on the wages paid their employees, or whether their efficiency was cut during the working day—steel mills, petroleum refineries, smelters, railroads.

Incidentally, I was noticing that picture up there of that Pennsylvania locomotive. It could not operate within the city of Los Angeles. It would cost them $500 an hour 24 hours a day.

We have closed down 1½ million incinerators. We have helped our electrical utilities obtain more gas for their steam plants. We have issued 5,000 citations in the last 3 years, and levied half a million dollars in fines.

Despite this, we still have smog.

There remains one source of air pollution beyond our power to control. Every day in Los Angeles County nearly 3 million automobiles are burning 5½ million gallons of gasoline, and fouling our air with 8,000 tons of contaminants. These emissions include 64,000 tons of carbon monoxide, 300 tons of oxides of nitrogen, and 1,050 tons of hydrocarbons.

Our scientific consultants term these substances "toxic air contaminants." They are poisons. To guard our residents against a possible air-pollution disaster, such as occurred in Costa Rica, Mexico, Belgium, and London, resulting from a concentration of these poisons, we monitor the air 24 hours a day. That monitoring program costs Los Angeles County a half million dollars a year.

To understand the unique role of motor-vehicle exhausts in the Los Angeles smog problem requires further explanation.

On many days each year the Los Angeles Basin becomes a great closed room as a layer of warm air moving off the Pacific clamps an invisible ceiling down tightly above us.

Here, gentlemen, I wanted to submit three comparative pictures taken from the same spot, where it shows the ceiling clamped down over Los Angeles. In other words, that is a layer of hot air which is holding the pollutants in the colder air down in the breather area where most of our 5 million people live.

The second picture is what happens 20 minutes later. One is taken at 9 o'clock in the morning and the second one was taken 20 minutes to half hour later when the surface air was starting to heat up and the so-called smog or pollutants was starting to disperse into the upper air. This third picture was taken around midday when you have the sunlight having cooked the pollutants, largely from automotive exhaust, and giving us our typical smog problem.

It is one these days that a bluish, low-hanging, eye-irritating, crop-damaging cloud of polluted air called smog makes its presence felt throughout the county.

Although composed of more than 50 different important air polluting substances, the brand of smog produced in the Los Angeles Basin is unusually rich in compounds known technically as hydrocarbons—or, more simply, gasoline vapors.

If any single pollutant found in the Los Angeles atmosphere were to be selected as being the most significant the pollutant named would be hydrocarbons.

In 1950, Dr. A. J. Haagen-Smit, a scientist of the California Institute of Technology and consultant to the air pollution control district, performed an experiment that was to have far-reaching effects on air pollution control activities in the Los Angeles Basin.

By confining certain types of hydrocarbons under radiant energy, or sunlight, with oxides of nitrogen (both of which are normally found in our atmosphere), Dr. Haagen-Smit produced a product that looked like, smelled like, and acted like smog. It caused eye irritation, produced the typical pattern of smog damage on vegetation and caused rubber cracking—all of these standard symptoms of Los Angeles smog, and which are becoming increasing symptoms of air pollution throughout the other major urban areas of the United States.

It was from this experiment, and many others like it, that the groundwork was laid for the most significant aspect of air pollution control in Los Angeles County.

Supported by other findings, including actual samplings of polluted atmosphere, these experiments had demonstrated that the Los Angeles atmosphere did indeed possess, in addition to all its other air polluting sources—a factory in the sky.

They took these raw materials and through this sunlight and energy created something that was entirely foreign to it.

There we go back again to the hydrocarbons as the precursor, as the important element that creates what is known as a very toxic air pollution.

Today, control of hydrocarbon in the Los Angeles area has been completed with one major exception. We have required oil refineries to go to great lengths in controlling evaporative losses from their storage tanks, from their skimming ponds, from their loading racks, where they load the trucks to service the 8,000 service stations in the area.

All of them have installed vapor controls so that the entire loss of hydrocarbons from any other source than automobiles is negligible.

In other words, we, in searching for establishment of the responsible element which causes our problem, have obviated to the maximum limit of engineering science, all other sources.

Ever since the hydrocarbon theory of smog formation was enunciated in 1950, attention has focused on automobile exhaust as the primary source of the ingredients of smog. The theory, which has been confirmed by many experimenters and observers, holds that hydrocarbons—the type of chemical compounds that make up gasoline—react with oxides of nitrogen when stimulated by sunlight, and this reaction forms smog.

The automobile engine not only emits a stream of burned, partially burned, and raw hydrocarbons, but it also creates great volumes of oxides of nitrogen.

Oxygen and nitrogen, the main constituents of air, remain chemically separate at normal atmospheric temperatures. At high temperatures, however, they unite in varying proportions and form a number of compounds, which are grouped under the name, oxides of nitrogen.

When the automobile engine sucks in air to burn with the gasoline, it exposes oxygen and nitrogen to the heat of the combustion chamber. Oxides of nitrogen are formed and are blown out of the tailpipe, thoroughly mixed with hydrocarbons.

Much as dynamite remains inert until the proper detonation sets off an explosion, the exhaust mixture hangs near a critical balance until it is triggered by sunlight. Then like a brushfire, the reaction spreads through the mass and forms smog.

The problem of eliminating this contribution from our 3 million rolling smog factories has been divided thus: either do something to the mixture before it enters the combustion chamber—the induction phase or to the exhaust after it has burned—the exhaust phase.

The possibility that something may be done during the burning process itself also is being considered.

Some of the major technical problems encountered in developing controls for motor-vehicle exhausts are explained in considerable detail in several publications I shall offer your committee in a moment.

Significant as the motor vehicle may be to the occurrence of smog in Los Angeles, there is good reason to believe that auto exhausts are not exclusively of concern to the Los Angeles area, alone.

Every day automobiles in the United States are poisoning the air with nearly 180,000 tons of contaminants: 17,000 tons of hydrocarbons, 7,000 tons of oxides of nitrogen, 154,000 tons of carbon monoxide, and 500 tons of sulfur dioxide.

Even more alarming—gasoline consumption in the United States is increasing at the rate of 4 to 5 percent per year. In little more than 20 years this appalling amount of air pollution will have doubled.

It has been suggested by some authorities that communities everywhere in the Nation have a smog threshold. Up to a certain point pollutants may be emitted freely into their atmosphere without creating serious problems.

Beyond that point, continued pollution output will create air pollution problems—possibly of the type experienced now in Los Angeles, and to a lesser degree, in San Francisco, San Diego, and other metropolitan areas.

This possibility is suggested strongly by field studies performed by Dr. Fritz Went of the California Institute of Technology. In research studies of smog conditions throughout the world including Paris, Milan, and some places in South Africa and South America, Dr. Went undertook to determine the date at which smog first occurred in three cities, as evidenced by typical Los Angeles smog-type damage to growing vegetation.

He is a plant pathologist of considerable note. The damage done to vegetables of various types by air pollutants is as definite as your personal doctor can tell whether you have measles or mumps or chicken pox or something else.

The reaction of sulfur, the various pollutants, on plants is very definite, and we use it extensively in processing cases in court.

In three cities investigated—London, Paris, and Los Angeles—Dr. Went discovered that smog, as measured by plant damage, first occurred noticeably when gasoline consumption reached 12 tons per square mile in the metropolitan area.

One may therefore speculate as to the consequences of continued growth in many of the Nation's metropolitan and urban areas and as to the results of increasing motor vehicle usage with resultant increases in the output of hydrocarbon-bearing exhaust.

Other industries have been controlled by cleaning up the processes of manufacture. With the automobile industry it is not the process of manufacturing that pollutes the air, it is the product itself.

By its very nature it continues to cause damage as long as it is operated as it was built to be operated. The automobile industry builds machines—and they are air polluting machines. The required controls must be built into those machines at the source—at the factory.

The automobile industry is a national industry. Its raw materials, its subassemblies, its finished products move in interstate commerce. Upon its well-being rests a good portion of the well-being of our economy. Its products and its ideas have remade the appearance and the social structure of the United States.

Air pollution does not recognize political boundaries. The problem of Los Angeles is also the problem of its neighboring counties. The problem of New York is the problem of its neighboring States. The problem of Detroit extends across an international boundary. Local control, or State control, may not be adequate in such situations.

There is a difference of scientific opinion as to the quantities of certain constituents of auto exhaust that can be tolerated. Some authorities have found evidence that strongly points to the carcinogenic effects of chemicals in auto exhaust.

It has been inferred that the rise in the incidence of lung cancer may be due in part to this type of air pollution.

Scientific and medical questions of this type, having such an important bearing on the public health, should rightfully be resolved by the Federal Government, so that a uniform standard of exhaust emission and control may be established where necessary.

For all of these reasons, the basic principles of this bill are sound. As to the details, there are undoubtedly many questions that may be raised in the fields of medicine, engineering, and law. I am an expert in none of these, and I leave those questions to those who are qualified. But, as an administrator in this area, and I trust, an enlightened layman in these specialties, I can heartily endorse the broad concept of this legislation: that the Federal Government should concern itself increasingly with the problem of motor vehicle exhausts and with the establishment of standards for the control of air pollution from automobile exhaust.

Representative Schenck is to be commended for his vision in proposing it.

This is a complex problem, and a workable piece of legislation that will deal successfully with its many aspects requires broad and deep analysis. If this committee can draft such legislation as will provide

a genuine and necessary contribution to the health and well-being of the Nation, it is to be greatly commended.

Thank you very much.

Mr. LOSER. Thank you, Mr. Griswold.

Mr. Schenck.

Mr. SCHENCK. Mr. Chairman, there are a number of questions that I have, but in the interest of time, I want to forego that privilege.

I wish to express my deep appreciation to Mr. Griswold.

Mr. LOSER. Mr. Griswold, possibly one of the other gentlemen will have a question.

Mr. Beamer?

Mr. BEAMER. No questions, Mr. Chairman.

Mr. LOSER. Mr. Bush?

Mr. BUSH. I can only say that Mr. Griswold effected quite an organization out there to look after their air-pollution problems that apparently exist there.

Mr. GRISWOLD. Thank you.

Mr. BUSH. I commend you for it.

Mr. LOSER. Without objection, the photographs offered by Mr. Griswold will be made a part of the record.

Mr. SCHENCK. May I suggest, Mr. Chairman, that Mr. Griswold be asked to make some comments on the back of the photographs? That may be helpful.

Mr. LOSER. Would you do that, Mr. Griswold?

Mr. GRISWOLD. I will be glad to, sir.

(The photographs referred to follow:)

FIGURE 1.—Taken at about 9 a. m. in the morning on a day when heavy smog is predicted. There is no wind and is a surface inversion (layer of hot air of great depth which holds pollutants in the cold air near the ground). This pollution is largely from auto exhaust.

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FIGURE 2.—Taken same day as figure 1 about one-half hour later. Note "inversion" is lifting as surface air heats and lifts hot layer. Sunlight is also "cooking" or irradiating the pollutants.

FIGURE 3.—Taken about 11 a. m. showing a typical eye-smarting, crop-damaging, visibility-reducing Los Angeles smog.

Mr. LOSER. Is Mr. Larson present?
Mr. LARSON. Yes, Mr. Chairman.
Mr. LOSER. Next will be Mr. Gordon P. Larson, from Wayne, Pa.

STATEMENT OF GORDON P. LARSON, EXECUTIVE VICE PRESIDENT, OXY-CATALYST, INC., WAYNE, PA.

Mr. LARSON. Yes, Mr. Chairman. I have a short statement I would like to present, if I may.

Mr. LOSER. Would you identify yourself, please?

Mr. LARSON. Mr. Chairman and gentlemen of the committee, my name is Gordon P. Larson. I am executive vice president of Oxy-Catalyst, Inc., at Wayne, Pa. Since 1948 I have been engaged in scientific investigations of the causes and effects of air pollution and in engineering applications to processes for correcting emissions of pollutants to the atmosphere.

I am here at the invitation of the committee, but only for the purpose of discussing the status of technical developments for controlling exhaust gases from internal-combustion engines. Neither as an individual, nor as a representative of my company, would I be qualified to testify on the merits of the present bill, H. R. 9368, or on the legal approaches to the control of exhaust gases.

Rather, it is my purpose to inform this honorable committee that a process has been developed and tested under my personal supervision and by an independent laboratory which shows that the unburned hydrocarbons in the exhaust of gasoline-driven engines can be eliminated.

The process which is capable of removing more than 80 percent of the combustible constituents, including hydrocarbons, is that of catalytic oxidation.

No other equipment or process has been reported at this time which compares in effectiveness for removing hydrocarbons from exhaust gases. Many lines of investigation have been pursued by competent laboratories to correct this problem.

Engine changes, fuel changes, and carburetor devices have been carefully investigated as a means for eliminating hydrocarbons in the exhaust. Afterburners and filters have been tried without success.

In its simplest terms, this process requires the equipping of a vehicle with a catalyst chamber which approximates in size the conventional muffler.

The gases from the engine, after addition of air, are passed through a catalyst which combines the oxygen with the unburned constituents of the exhaust, thus obtaining heat from the combustion to produce harmless carbon dioxide and water which is emitted to the atmosphere.

This process operates in temperature ranges between 900° F. to 1,200° F. and, consequently, the catalytic chamber requires a layer of insulation around it which, together with an air-intake device, comprise the only mechanical additions to an exhaust system.

No smoke or odors are emitted from the catalyst chamber during all phases of driving. Using the present techniques which are acceptable to investigators for measuring hydrocarbons, the elimination of those compounds will range from 80 to 100 percent when driving under city traffic conditions.

The development of this invention to its present state is the result of 10 years of effort of Mr. Eugene J. Houdry of Ardmore, Pa.

Mr. Houdry is the inventor of catalytic cracking which was introduced into this country for the petroleum industry in 1930.

His work in the petroleum field led him to the conclusion in 1948, that exhaust gases and hydrocarbons from all sources were dangerous, affected the health and well-being of the public, and must be eliminated.

Since that time he and his associates in Oxy-Catalyst, Inc., have worked unceasingly at tremendous personal sacrifice to find an inexpensive catalyst and so engineer the process that it could reach the public at nominal cost.

The great amount of time involved to successfully reach this point came about in the search for materials which would resist poisoning by the lead compounds which are a part of the exhaust gas system.

All known catalysts, prior to his development, no matter what their cost, were quickly poisoned by lead compounds and consequently made the catalytic process impractical for use by the general public.

In addition to finding the catalyst, it was recognized that the container for the catalyst and its adaptation to the vehicle must not hamper the efficiency of the engine or inconvenience the driver.

From the development work that has been completed and the tests that have been conducted on the road, the process will maintain the efficiency mentioned heretofore for a minimum of 17,000 miles of driving.

Beyond this point, procedures can be used to reestablish the efficiency of the catalyst which will be less costly than changing the oil in the crankcase on the milage schedules recommended by the motor industry and the oil industry.

Any public-inspection system, or the driver himself, will be able to determine the effectiveness of the catalyst by a small indicator on the instrument panel, equivalent to the device used today to indicate the condition of the battery, gasoline level, or oil pressure.

As to the final point, the cost of this apparatus, if it is needed and required for general usage, cannot be absolutely fixed at this time.

Some applied engineering, to fit the catalyst chamber to the automobile, remains to be done and the studies of manufacturing and assembling the unit in large quantities have not been completed.

It is estimated, however, that manufacturing costs of the catalyst chamber, insulation, air-inlet system and catalyst for mass production will not cost more than $30 for the average passenger car.

It is also believed that minor adaptations to our catalytic process can be made so that the catalytic process and such adaptation will serve as an acoustical muffler, thus replacing the conventional muffler. If this is done, the present cost of mufflers would be deductible from the above figure as the net first cost of this apparatus.

However, since the container would be of such materials as to withstand the temperatures which I have mentioned, it would be of such quality that it would last the life of the vehicle.

The present problem of the owner frequently replacing the conventional muffler at the very high cost for installation at the garage will be eliminated.

I have included as an exhibit to this statement, "A Review of the Pollution Problem for Engine Exhaust," which includes other types of engines such as the diesel, or the use of internal combustion engine indoors. I believe that this information may be helpful to your committee in considering the overall technical aspects of this important problem.

I wish to convey the thanks of Mr. Houdry and my associates for inviting us to be present and to commend this committee for being the first legislative group to consider controlling the emissions from exhausts.

Scientists and doctors who are familiar with the subject and the public who in our cities live in an atmosphere of exhaust gases are fully aware of the need for solving this problem.

Thank you very much.

(The document referred to follows:)

A Review of the Pollution Problem for Engine Exhaust[1]

By Gordon P. Larson

The records of the United States Patent Office clearly reveal the interest in removing dangerous contaminants from the exhaust of internal combustion engines. A variety of 80 patents, covering every possibility, has been presented by inventors over the past 48 years. The reason for this interest in the past is somewhat confusing since there has been no widespread concern about the contamination from exhaust gases. Investigations on carbon monoxide and lead constitutents focused the interest of some inventors but, generally, the exhaust was classified as "dangerous," or full of "impurities," and the proposed devices were supposed to "purify" the condition. It is interesting to note that analytical results on the nature of the exhaust, and what a given device would do, are conspicuously absent from most of the work.

Our present generation has observed the great increase in the use of petroleum products and the benefits to mankind which have resulted from the mass use of automobiles, buses, and trucks. While our attention was focused on our great and expanding economy, on two major wars and a serious depression, the widespread use of gasoline was gradually building an air pollution problem which first came to the attention of scientists and engineers interested in this field as a result of the Los Angeles smog problem. In 1951, the author reported to the Air Pollution Control Association the findings in Los Angeles, which pointed out for the first time that gasoline vapors are potential air pollutants. (1) The work done in 1950 and 1951, together with the subsequent reports, clearly demonstrated that certain types of hydrocarbons were capable of oxidizing in the atmosphere to produce a variety of effects. Under some conditions, the photochemical reaction which takes place between readily oxidized hydrocarbons and oxides of nitrogen in sunlight will produce an eye irritation, a typical type of damage to leafy vegetables, create haze and form ozone. (2) (3) By 1953 the sources of hydrocarbons in the Los Angeles area had been reported, including the amount of hydrocarbons from vehicular traffic. The final conclusive reports, showing the distribution of gases in the Los Angeles atmosphere, clearly showed the role played by traffic in producing a localized concentration of hydrocarbons when adverse weather conditions prevailed simultaneously with the traffic peak. (4) The conclusion that auto exhaust must be controlled in Los Angeles was inescapable.

For several years a parallel interest has been expressed on the subject of automobile exhausts in Paris and London. Air pollution control officials in several United States cities have reported occasional incidents of eye irritation under unusual weather conditions. Also public complaints against the odors from buses and diesel trucks appeared in the newspapers of many cities.

The analyses of the effluent of automobile exhaust and diesel exhaust, as far as have been made to date, were surprising to a number of people. While lead compounds and carbon monoxide have been of interest, the unburned fuel

[1] Presented at Mid-Atlantic States Section APCA, Philadelphia Pa., November 28, 1956.

in the form of gasoline or partially oxidized gasoline, had been given little attention. It should be noted, however, that the improvements in engine design over the years resulted in increased engine efficiency and a reduction of carbon monoxide.

The publications of the results of study in Los Angeles, and subsequent discussions in Detroit, led to the formation of technical committees in the automotive industry to make a more complete analysis of automobile exhaust and to study methods for reducing the contaminants. These studies have been going on intensively since February 1953. While limited data are available on analyses from all types and conditions of engines, the most significant air contaminants shown in tables I and II may be considered as typical for automobile and diesel engines in average mechanical condition. (5) (6) Each of the items listed is considered to be a contaminant having some pollution effect on indoor and outdoor atmosphere but, of course does not represent a complete analysis of every type of compound in the exhaust. Table III gives an indication of the total contribution of various types of vehicles in city traffic.

Inasmuch as we are woefully lacking in information on the effects that all these materials might have on health, each person may judge any bad effects and condemn the exhaust from his own personal experience. An author hesitates to classify the contaminants and their most potential effect. However, in the interest of attempting to clarify some of the considerations which should be given to a study of this problem, table IV attempts to outline the major effects which may be expected, the particular set of contaminants causing the effect and the vehicles which contribute to the effect.

TABLE I.—*Automotive engine exhaust*

	Hydrocarbons as parts per million of hexane		Oxides of nitrogen (parts per million)	Carbon monoxide (volume percent)	Aldehydes (parts per million)
	Percent fuel unburned				
Idle	4.3	810	8	6.2	88
30 miles per hour	1.6	322	1,600	1.0	260
50 miles per hour		170		2.2	
Acceleration	1.2	285	4,000	1.3	1,360
Deceleration	17.4	4,520	17	5.4	193

NOTE.—Other constituents—H_2, SO_2, SO_3, CO_2, H_2, N_2, O_2—organic acids, alcohols, lead compounds, smoke.

TABLE II.—*Diesel exhaust*

	Hydrocarbons as parts per million of hexane	Oxides of nitrogen (parts per million)	Carbon monoxide (volume percent)	Aldehydes (parts per million)
Idle	10	60	0.1	10
Acceleration	10	800	.1	20
Cruise	10	200	.1	10
Deceleration	30	40	.1	35

TABLE III.—*Total hourly emission based on a city driving pattern*

	Carbon monoxide (SCFH)	Oxides of nitrogen (SCFH)	Formaldehyde (SCFH)	Hydrocarbons (pounds per hour)
Diesel	2	5.4	0.24	0.47
Gasoline	194	3.8	.17	1.24
Propane	96	4.9	.11	.57

TABLE IV

Major effects of known contaminants	Causes		
	Auto exhaust	Diesel exhaust	Liquid petroleum exhaust
Street level or public annoyance (odors and soiling).	Aldehydes-organic acids and sulphur. Compound.	Aldehydes-organic acids. Smoke.	Aldehydes-organic acids.
Contribution to general pollution (effects: Eye irritation, crop damage, and haze).	Partially oxidized. Hydrocarbons. (Photochemical reaction in the atmosphere.)		
Health (general atmosphere) (potential carcinogenic effects).	Partially oxidized. Hydrocarbons.		
Concentrated local effects tunnels-terminals enclosed operation (annoyance and soiling).	Carbon monoxide. Oxides of nitrogen.	Oxides of nitrogen. Aldehydes-organic acids. Smoke.	Aldehydes-organic acids. Carbon monoxide.
Health (indoor operation) (potential carcinogenic effects and cumulative poisoning).	Carbon monoxide. Lead compounds. Smoke (carcinogenes). Oxides of nitrogen.	Smoke (carcinogenes). Oxides of nitrogen.	Carbon monoxide. Oxides of nitrogen.

This evaluation points out that the smoke from diesels is not important to the general pollution problem and the health problem in the outside atmosphere, insofar as is known. It must be recognized that the quantity of the material that is produced by each of the types of engines is important in the study of the problem. The amount of diesel fuel consumed in an area, compared to gasoline, is quite insignificant. This in no way, however, minimizes the annoyance from diesels at street level in the downtown congested streets, or to the passenger car occupants who follow behind a "smoker" on the highway. The density of passenger vehicular traffic can create local street level problems, as well as contribute large quantities of contaminants to the atmosphere.

An indication of the contribution from general traffic can be obtained by measuring the hydrocarbons in the atmosphere in the downtown areas, or by determining the extent of the ozone formation in the given area. (8) Street level studies should include carbon monoxide concentrations under all traffic conditions. Experienced air-pollution officials are well aware of the importance of public complaints and, while these complaints will not arise from carbon-monoxide concentrates, or from general pollution contributed to automobile exhaust, the smell produced by aldehydes and sulfur compounds do give rise to considerable public complaints. These generally will be found originating from the operation of diesel buses and trucks. The worse condition, from the public point of view, is at congested intersections, in tunnels and bus terminals, or in driving behind these forms of transportation.

Experience clearly shows that vehicles cannot be operated indoors or underground without adequate ventilation. The use of forklift trucks in storage facilities has resulted in a demand for reducing carbon monoxide from these vehicles. Underground operations using heavy equipment represent an entirely different condition, requiring stringent measures to protect the workers. In this case, health authorities are concerned not only with the strong smell and carbon monoxide but with potential harmful health effects produced by high concentrations of oxides of nitrogen.

The eye irritation and crop-damage problem, while not experienced to any marked degree in cities other than Los Angeles, is causing increased concern in San Francisco, Paris, and London. Crop damage has been found in these areas and interested workers in this field would be advised to make observations in other areas for the first indication of crop damage.

Finally, the reports on carcinogenic materials from the oxidation products of gasoline vapors give rise to considerable speculation on the effects to the general population as this problem continues to increase. (9) While no extrapolations to human beings can be made from the animal experiments reported to date, it is a certainty that this research will continue to a point where firm conclusions can be drawn.

As certain signs of danger are already recognized, as evidenced from the bad effects underground and indoors, from the results in Los Angeles and from the

carcinogenic nature of some of the hydrocarbon in relation to animals, there is little need to debate the necessity for reducing the contaminants in automobile exhausts. Each community should study carefully the effects of traffic by taking measurement of the contaminants in the air. Statistical studies on the traffic conditions should be made and records maintained on gasoline consumption and vehicle registration.

It is this author's opinion that time is running out and that effective control measures must be instituted progressively. Scientists in the automotive and petroleum industries already are studying the improvements which might be accomplished by changes in fuel, or in redesign of automotive engines. The automobile industry technicians and several private inventors are working on devices which would reduce the contaminants in the exhaust. Meanwhile, too little attention is being given to planning the community to avoid traffic congestion. Traffic engineering should recognize the importance of the exhaust contribution to air pollution as a result of the excessive stop-and-go driving. Improved public transportation should be studied from the point of view of the air-pollution control officials and all city planning groups should seek the services of trained air pollution control authorities.

The understanding of the exhaust problem has clarified gradually at the technical level during the past 5 years. The public has become increasingly concerned about the subject and Government officials cannot afford to ignore the editorials and increased public complaints which are arising in metropolitan areas. Neither funds nor sufficient numbers of technically trained persons have been provided to the various air-pollution departments throughout the country to study the impact of exhaust gases in the various cities. Full support has been given to programs for the elimination of visible smoke, but a far more serious problem exists in the invisible hydrocarbons which can be detected and evaluated only with expensive equipment and highly trained personnel. While the program to eliminate visible emissions should be continued on all fronts, cities and counties should also provide the necessary tools to measure this invisible form of pollution as a foundation for determining a complete control program in each community.

The discussion of the basic factors which result in sulfur compounds, oxides of nitrogen, and incomplete combustion products in the exhausts of internal-combustion engines, is beyond the scope of this paper. A brief review of the progress made by the various groups working on this problem will give some indication of its complexity. Over the past 2 years, research sponsored by the petroleum industry and the automotive industry, on fuel changes which might influence the exhaust, shows no immediate promise and some reports indicate that fuels which might possibly be made available, without complete process changes in the petroleum industry, have little influence on the exhaust products.

Studies on the driving conditions in city traffic show that the largest tonnage of hydrocarbons is emitted during the deceleration cycle. Several reports have been published on the benefits which might be expected by decreasing the flow of fuel to the carburetor during deceleration. (10) This, theoretically, could be accomplished by breaking the manifold vacuum, or by a cutoff valve on the carburetor. Engineers of the Automotive Exhaust Fume Committee in Detroit have developed several such devices, along with the Holly Carburetor Co., and others. Recent reports indicate that the best of these devices do not reduce the hydrocarbons as much as was expected and, of more importance, impose difficulties on the operation of the vehicle. Whether or not work will continue in this direction at this time is unknown, but there is a strong belief in many quarters that either a complete change in engine design, or the removal of the contaminants by a device on the exhaust itself, will be necessary. While engine changes may be expected, even to the extent of replacing the piston engine, the problem to be solved for some years to come revolves around the existing automobile engine.

For the past 4 years it has been evident that a muffler of practical size, using an oxidation catalyst, could be employed for the reduction of the unburned and partially burned contaminants in the exhaust, if certain factors resulting in high cost could be overcome. Oxy-Catalyst, Inc., of Wayne, Pa., has been marketing, during this period, a muffler for gasoline engines operating indoors. (11) One design is employed on vehicles using white gasoline, or propane, for fuel. Another design is available for leaded gasoline. Catalyst life ranges from 1,000 to more than 3,000 hours, depending upon the usage and fuel. Above 95 percent of the carbon monoxide, hydrocarbons, and smoke are eliminated. However, the catalyst employed is expensive and beyond the reach of the general public, if applied to large numbers of gasoline-driven

vehicles. Since all oxidation catalysts are poisoned to some extent by lead in the gasoline, the replacement of a catalyst will be an important factor in the cost to the public. Thus, the ultimate success of this process is dependent upon an inexpensive catalyst which will have a reasonably long life. Oxy-Catalyst recently has reported the development of such a catalyst. The reports on the use of this catalyst, at its present stage of development, show a reduction of hydrocarbons and other partly burned materials in excess of 85 percent averaged over 10,000 miles of driving. The catalyst is of practical size and weight for application to passenger vehicles.

The Clayton Manufacturing Co. in Los Angeles has reported the development of an afterburner device employing a spark plug to ignite the mixture in the exhaust of engines above 600 cubic inches displacement. Laboratory reports show 90 percent elimination when the combustion chamber of this equipment has reached 1,200° F. No report is available on starting the apparatus, or the degree of elimination when the vehicle is on the road. Several of these devices are being installed on gasoline-engine buses in California.

While the analytical data show only small quantities of contamination coming from diesel engines, the odor problem is of serious concern in underground operations, in closed areas, and in the immediate proximity of these vehicles at street level. Proper maintenance of diesel engines is an important factor in minimizing the odor complaints. However, here again, neither changes in fuel or maintenance will eliminate the problem.

Serious difficulties are encountered in removing the small amount of contamination present in the diesel exhaust. The employment of an oxidation catalyst on this exhaust, without the addition of some fuel, is out of the question on a two-cycle engine. Oxy-Catalyst has demonstrated a prototype unit employing small additions of fuel and a heat exchanger in the muffler to eliminate successfully the smoke and odor. This catalytic process is being tested by a diesel-engine manufacturer, with the view to solving certain engineering problems and determining size and cost factors. This same company currently is marketing a muffler for four-cycle engines which gives some degree of relief where the engine is under load for a good portion of the time.

No successful work has been reported on direct chemical treatment or scrubbing systems for exhausts, except for stationary engines in underground operations. Even here, such processes are costly and of low efficiency. More than 25 universities, private research laboratories, and industrial concerns currently are engaged in studying the many aspects of this complex problem. It is a certainty that several solutions will be proposed and there is reason to believe that progress will be made toward the final goal.

At present, it appears that the application of oxidation catalysts to the exhaust problem offers the best promise for an immediate solution. The organic substances which create the worst air pollution and health problems can be rendered harmless. Carbon monoxide can be oxidized readily and carbon and smoke particles greatly reduced. The use of an appropriate oxidation catalyst also holds promise of reducing the oxides of nitrogen which are so important in confined areas.

The important contribution of Eugene J. Houdry of a new lead-resistant, low-cost catalyst to do this job is a major step forward. The final cost to the public should be promptly determined and weighed in terms of good public relations and the desire to provide a cleaner environment.

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Mr. LOSER. I have the impression that you have this almost solved.

Mr. LARSON. On the basis of finding the catalyst, applying it, applying it to a vehicle on the road, the fundamentals of the problem are solved.

There remains the determination of the final cost in mass production, and its actual application, sizewise, and fitting, to automobiles.

Mr. LOSER. I believe you fix the cost at a maximum of $30.

Mr. LARSON. That is what it appears to us to be. We are catalyst manufacturers, and we are studying the mass production problem of the metal manufacturing. That will determine the final cost.

Mr. LOSER. Without objection, the additional statement of Mr. Larson has been incorporated in the reference. That is a review of the pollution problems for engine exhaust.

Thank you very much.

Mr. Schenck.

Mr. SCHENCK. Mr. Chairman, I do not have any question to ask Mr. Larson, but I want to express my grateful appreciation for his fine statement and for indicating that this can be done.

Thank you.

Mr. LOSER. Mr. Larson, if you would remain a moment, it is possible that these other gentlemen might want to ask you a question or two.

Mr. Beamer.

Mr. BEAMER. I have one question, Mr. Chairman.

I do not want to pry into the affairs of your corporation, but has this been presented to the automotive industry, and, if so, what has been their reception?

Mr. LARSON. The automotive industry has conducted tests over the past year of this catalytic process, and we are in the course of studying various approaches to the next stage of the problem, which is studying the final cost and fitting the application to the automobile.

Mr. BEAMER. Have you received some encouragement from the industry?

Mr. LARSON. Yes. We have had the finest of cooperation, and the test of the catalyst has only been very recently completed by them.

Mr. BEAMER. Thank you, Mr. Chairman.

Mr. LOSER. Mr. Bush?

Mr. BUSH. Congressman Beamer asked the same questions that I had in mind.

I just wondered if you were cooperating with the people in the automotive field, and what your reception was. You seem to be very sure in your answer, and then at the end of your statement you say there is still a lot to be done in the way of engineering and that kind of thing.

Mr. LARSON. There is some more work to be done.

Mr. BUSH. How long is it going to take to do that?

Mr. LARSON. I cannot answer specifically how long. Oxy-Catalyst is studying the problem itself of determining the mass production problem and its cost. We are talking also with metal manufacturers who are interested in this process, and who would be capable of doing the manufacturing and the studies.

We are also talking with the motor industry at the technical level, to determine whether or not they might go ahead with further studies on the manufacturing.

So we are working at the present time on three fronts, and we are at this point today simply because our tests have been completed on what the catalyst will do, and the motor industry has only recently conducted a similar independent test to arrive at what they conclude the catalyst will do.

So we are at this mass production metal study of the problem right now on three fronts.

Mr. BUSH. Thank you very much.

You are from a great State. I happen to be from Pennsylvania myself.

Mr. LARSON. I heartily agree, sir.

Mr. LOSER. Thank you very much, sir.

Dr. Fisher?

STATEMENT OF DR. WILTON M. FISHER, CHIEF, AIR POLLUTION MEDICAL PROGRAM, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, WASHINGTON, D. C.

Mr. LOSER. This is Dr. Wilton M. Fisher, Chief of Air Pollution Medical Program, Division of Special Health Services, from the Department of Health, Education, and Welfare, here in Washington.

You may proceed.

Dr. FISHER. Thank you, sir. We have supplied a written statement on the first two questions asked in your letter, sir, of March 1.

On the third question, the status of research on controlling air pollution through modification of automobile design, we were reasonably certain when talking to Mr. Jones that it would be covered during the morning, and then it seems that it was.

Most of the question on the extent to which the automobile may be contributing to the air-pollution problem was covered by Mr. Griswold. We have some additional summary statements supplied in the written text.

Mr. LOSER. Without objection, your written statement will be made a part of the record. We would be glad if you want to make some oral observations in connection with the matter.

Dr. FISHER. Thank you, sir.

(The document referred to follows:)

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,
PUBLIC HEALTH SERVICE,
BUREAU OF STATE SERVICES,
Washington, D. C., March 14, 1958.

Hon. KENNETH A. ROBERTS,
Chairman, Special Subcommittee on Traffic Safety, Committee on Interstate and Foreign Commerce, House of Representatives.

DEAR MR. ROBERTS: As a technical representative of the Public Health Service, Department of Health, Education, and Welfare, and as chief of the air pollution medical program of the Division of Special Health Service, I am pleased to have the opportunity to assist your committee in its hearings on H. R. 9368.

Attached to this letter are statements concerning (1) the present status of research on the toxicity of fumes on human beings; (2) the possible extent of automotive contribution to the air-pollution problem. Mr. Jones of your staff agreed that the third area in which you had indicated the interest of your committee, the status of research on the possibility of controlling some of the air-pollution problem through a modification of automobile design, can best be presented by other witnesses.

Sincerely yours,

WILTON M. FISHER, M. D.,
Chief, Air Pollution Medical Program, Division of Special Health Services.

THE PRESENT STATUS OF RESEARCH ON THE TOXICITY OF (AUTOMOBILE) FUMES ON HUMAN BEINGS

The major responsibility of the air pollution medical program of the Public Health Service is to determine whether or not community air pollutants modify the public health. Our concern is with all air pollution and not alone with that arising from the automotive engine. Our broad program at the present time does, however, provide for studying some fundamental problems in regard to the effects of certain components and groups of air components of air pollution connected with the use of the automobile. I shall discuss some of these later.

The interest of the Public Health Service and other Federad agencies in the automotive engine as a source of air contaminants which are of possible concern to the public health extends back at least 30 years. In 1927 and 1928 studies were made both by the Public Health Service and the Bureau of Mines of the problem of the auto exhaust and public health. These studies were made to clarify the problem as it related to carbon monoxide and tetraethyl of lead. It was the conclusion at that time that the discharge of carbon monoxide into community air, as long as it was not permitted to accumulate in confined spaces, was not of health signicance. It was also concluded that tetraethyl of lead, in the very small amounts that were then added to gasoline, did not create a health hazard from the auto exhausts that reached the community ambient air.

Although these are the prevailing opinions in the United States, even to the present time, we do not wish to leave the erroneous impression that these opinions are unanimous. Certainly they are not unanimous internationally, judging from the available medical literature on the subject. These two components of automobile exhausts, carbon monoxide, and lead compounds, have over the years continued to receive attention from scientists concerned with the public health. Finally, I must add that the possible hazard created by these materials may be changing, due partly to the increasing numbers of automotive units producing the exhausts and the engineering advances made by the automobile industry.

Over the years the other components known to be present in automotive exhausts have received some attention for public-health reasons; but, the amount of that attention has been less than the amount generally given to carbon monoxide and lead. Undoubtedly many possible reasons come to mind for these differences in emphasis, and I shall not go into these at this time. The need for consideration of the other components of auto exhausts has been emphasized recently.

I should like to review at this time for you the significant points which, as it seems to me, make it useful to evaluate the problem of the automotive exhaust gases and public health. Briefly, I shall consider this under two headings: Cancerigenic properties and irritative properties of auto exhausts.

It has been shown that auto exhausts contain substances which, when supplied to suitable experimental animals under appropriate conditions, will increase the

frequency of cancer. There has been some question of the relative amounts of carcinogenic agents discharged with the exhaust gases, but there has been little denial that such agents are so produced.

Incidentally, it may be noted that polycyclic hydrocarbons of known carcinogenic potency have been produced from the burning of even very simple hydrocarbons under special experimental conditions.

This is not to say that only the polycyclic hydrocarbons are implicated in experimental cancer production. Straight-chain hydrocarbons have also been claimed as culprits. Such straight-chain hydrocarbons may be active in more than one way. They have been shown to have a carcinogenic potential per se. But what may be of even greater significance in connection with the carcinogenicity of the straight-chain hydrocarbons is that they serve as solvents for, and carriers of, more potent polycyclic hydrocarbons, thus bringing the latter into more effective contact with the target issue.

Although the irritant property of automobile exhausts is discussed later, I must mention it at this point, since this property may have a significant relationship to the cancer potential of the exhaust gases.

Irritation per se may have a serious carcinogenic potential. Auerbach, of the Veterans' Administration, in his study of tobacco smoke and cancer, has shown that irritation of the mucosa of the tracheobronchial tree leads to hyperplasia and even to metaplasia of the mucosal lining. Although by inference one may see a relation between such metaplasia and bronchiogenic carcinoma, it is not possible to conclude that such metaplasia as is found in these cases will lead to carcinoma. Such irritation, however, may act in either of the two ways to be a factor in carcinogenesis. These are:

(*a*) Irritation, if it is mild, will cause a slowing down of the activity of the cilia of the mucosa of the air passages, and this will permit a longer period of contact between inhaled potential carcinogenic agents and the susceptible tissue.

(*b*) When the irritation is severe, denundation of the surface layers of the epthelium of the tracheobronchial tree will occur and thus the deeper more susceptible cells will be exposed to the action of any potential carcinogenic material that may be carried in the breath.

A final point to be made is that there has been a universally growing increase in lung cancer frequency. During the time that this fact has been recognized various environmental factors have been blamed for this increase. In regard to auto exhausts, I may say we know of no scientific data that have shown that the automotive engine exhaust specifically is, or is not, responsible for part of this increase of lung-cancer frequency. Although we strongly suspect relationship between air pollution and lung cancer, we do not now know that air pollution—considered in its entirety, of which auto exhausts provide only one part—is, in fact, related to the increase of lung-cancer frequency.

Now, if I may discuss some of the irritant qualities of auto exhausts, I will go on to say that automotive engine exhausts can irritate exposed membranous surfaces—eyes, nose, throat, and respiratory tract—is denied by no one who has ever had to stand about in a closed garage in which an engine was running. In such instances the gases were allowed to accumulate in a confined space to reach significantly high levels of concentration.

The eye-irritation phenomenon, at times complicated by throat irritation, that has been observed in the Los Angeles Basin, and to a lesser extent in other places, seems to be temporally associated with automotive traffic. According to California studies, this phenomenon is associated with vegetation damage and air haze. It is generally accepted that meteorology and topography are related to the occurrence of the eye-irritation phenomenon. This eye condition, to the best of our knowledge, is a subjective phenomenon and is manifested by discomfort and tearing and is not associated with any measurable eye injury. If for no other reasons, the symptom of eye irritation is of public-health significance, since it is associated with an unmeasured degree of apprehension among the residents, apprehensions as to what such an airborne irritant may be doing to their health.

We have been sufficiently impressed with the potential toxicity of certain exhaust components to spend considerable amounts of our moneys and our efforts to support studies of biological effects of auto exhaust gases, especially as regards certain components of those gases.

One of these that we are supporting is that being done by Dr. Joseph Gast at Baylor University College of Medicine, ouston, Tex. At our request he developed a mechanical unit to combine oxides of nitrogen with gasoline-contained hydrocarbons, irradiate the mixture with ultraviolet radiation, and to

expose animal tissues to the gas mixture under controlled conditions. Dr. Gast, a biochemist by training, is especially concerned with evaluating the effects of such a mixture upon known enzyme systems with the ultimate objective of providing us with information of how and where, in the cell, such air pollution may have its effect.

Another study in this general direction that we have arranged to have done for us is by Dr. William Deichman, University of Miami, Coral Gables, Fla. This work is concerned with the toxicity, both short- and long-term, of nitro-olefins, which can be derived from the interaction of the oxides of nitrogen and olefins under the influence of sunlight. The oxides of nitrogen and the olefins have their major origin, it would appear, from the automotive exhaust. Preliminary results indicate that these materials are very toxic and that at concentrations of the order of magnitude expected in the air of Los Angeles they produce the subjective effect of eye irradiation. Dr. Deichmann's findings have been supported by some preliminary studies made by Dr. Leslie Chambers of Los Angeles.

There are a large number of other studies which we have initiated through research grants or through contracts, and I shan't go into those at this time.

From the discussions presented it seems to me to be clear that investigative work must continue, possibly on an expanded scale, if we are to obtain definitive data on these and other possible effects of auto exhausts as they may contribute to community air pollution and thereby influence the health of man. Further, it seems to me that such biological investigations should be broadly directed as follows:

Laboratory exposures.—Suitable, selected species of animals should be exposed for prolonged periods under controlled conditions to adequately diluted auto exhaust gases. The many variables in the production of the exhaust as well as in its residence in the air must be considered in such experiments.

Community exposure.—Epidemiological studies should be made of the current hazard to human health from lead discharged from autos that use tetraethyl of lead in their fuel. The same general techniques would apply to other gasoline additives, e. g., boron compounds, carbonyl compounds, and possibly others.

Epidemiological studies should be made of the current hazard to human health from continued exposure to low concentrations of carbon monoxide, and further information should be gathered on the exposure levels to CO in community ambient air.

Possible Extent of Automotive Contribution to the Air Pollution Problem

There have been few studies made of the contribution of the automobile to urban air pollution. Those that have been made have used different techniques, for different times, at different locations and under different circumstances. The results of these varied studies indicate that automobile engine exhausts constitute from 10 to 60 percent of the gaseous pollution in the urban atmosphere. These exhausts contain various proportions of organic matter, including both saturated and unsaturated hydrocarbons, aldehydes and organic acids, and other partially oxidized fuel components. In addition, auto exhaust contains nitric oxide, which oxides in air to nitrogent dioxide.

The auto exhaust pollutants about which we know the most, with respect to their effects on health, are carbon monoxide and lead compounds. Generally speaking, the levels of these substances found in urban atmospheres have been so low as to be of no probable health significance in the light of present knowledge. However, in recent years a number of new additives, such as the boron compounds and the carbonyls, are being used in gasoline, and with respect to these our information is meager.

The pollutants considered of most significance in automotive exhaust include the hydrocarbons resulting from unburned and partially burned gasoline, and the oxides of nitrogen. The chemical group known as hydrocarbons includes an enormous number and variety of substances. Measurement and differentiation techniques for these substances are difficult, tedious, and expensive. We know little about the long-term effects of breathing minute quantities of these substances. Measurements that have been made of these substances have shown that their levels fluctuate widely, depending upon the time of day, season of the year, local weather conditions, topography, condition of vehicles, and makeup of fuel

used. One recent analysis of the hydrocarbons from a "typical" automotive exhaust identified the following substances:

Ethane	Butadiene-1,3	1,3-pentadiene-trans
Ethylene	Isopentane	n-Hexane
Acetylene	3-Me-butene-1	2,4-Di-me-pentane
Propane	n-Pentane	Me-cyclopentane
Propene	Pentene-1	3-Me-hexane
Isobutane	2-Me-butene-1	2,3-dimenthylpentane
Propadiene	Pentene-2-trans	Cyclohexane
n-Butane	Pentene-2-cis	n-Heptane
Iso-butene	2,3-Di-me-butane	Benzene
1-butene	2-me-pentane	n-Octane
me-acetylene	3-Me-pentane	Toluene
Butene-2-trans	Cyclopentane	
Butene-2-cis	2,3-Di-me-butene-1	

Dr. FISHER. As to the present status of research on the toxicity of fumes on human beings, there is little direct work on the human. There are some studies in Los Angeles of the effect of Los Angeles smog on humans. This is an observation on patients known to the investigating physicians during smog episodes. There has been a small amount of work which is not available to us publicly, of the effect of partial burning and of complete combustion of some hydraulic fluids, lubricants, and fire-fighting equipment.

This, we suspect, has been done in the Department of Defense. We have very little information on its ourselves yet.

Most of our work has been involved in the air-pollution programs concerned with the aerometrics of air pollution and with the physiologic response of animals to what materials among the air pollutants we could recognize. We are a national program. We are concerned with all phases of air pollution, community air pollution. We have some studies underway which continue the studies of coal smoke, oxides of sulfur. Most of our newer work has been directed toward the hydrocarbon type air pollutant, the hydrocarbon oxide of nitrogen, ultraviolet light, some by combination. We have a number of studies on basic toxicology, and it is quite basic toxicology, and tissue homogenates, working with very simple systems, all the way from bacteriologic studies up, to some studies on larger, intact animal colonies. We are trying to develop a better catalog of the acute effects of various pollutants on animals. We are beginning to move into the field of chronic behavior on some animals, those which show most promise in acute studies. The work on cancer is largely that of the cancer institute. They have been in business a long time. They have a very large staff and a very large budget, and they have started some work in the field of air pollutants and cancer.

Some work is done here at the Institute, and some of it is done at Los Angeles.

I am with the medical program. We are concerned with epidemiology, with studies of communities, with populations in communities, looking for diseases which may be correlated with pollutants.

We are trying to construct descriptions, air pollutant descriptions, of various cities where these studies are going on. We work very closely with an engineering counterpart unit here in Washington, and with a very large laboratory unit at the Taft Center in Cincinnati.

Our toxicology laboratories are in Cincinnati. The ultimate goal, of course, in our work, is to try to correlate the toxic studies we are

performing on animals with the effects we may be able to find in humans. At this time, we recognize eye irritation and irritation of the nose, throat, and as an effect becoming increasingly prominent in this country.

It was first described in large numbers in Los Angeles, of course. As to the more serious effects, we can only guess, search and look. In talking with Mr. Jones, he suggested we comment on any cancer study or any cancer effect attributed to any one of these compounds.

That is an expensive procedure, both from the standpoint of money and of time. The time for proving out a carcinogen, of a cancer causing agent, if we are lucky, becomes nearly a decade, sir.

This is from findings and effect and some susceptible system which, in some cases, might be a mouse, and in other cases might be other animals, other types of animals, and then proving out this effect on humans.

It describes effects which say that some materials are carcinogenic unfortunately seem to be based pretty well on animal response to the agents tested.

We do quite a lot of soul searching over the possibility of translating that to human lung experience. I am afraid those are rather scattered statements, Mr. Chairman.

Mr. LOSER. Thank you very much.

I wonder if Mr. Schenck would like to ask Dr. Fisher any questions.

Mr. SCHENCK. Mr. Chairman, I would just like to comment.

I have a letter here from Dr. Fisher dated March 4, 1958, to which he attached a copy of the statement sent by the Department of Health, Education, and Welfare, to the chairman of our entire committee, Mr. Harris. I could not agree less with the statement and with the letter from the Department.

It would appear to me that the Department here is taking a very lighthearted look at the seriousness of this whole thing, and would have us feel that we ought to wait a decade, or some other long period of time, before anything can be done or started.

It would seem to me, certainly, with the responsibility faced by the Public Health Service, that there should have been some indication that the Public Health Service had a very definite feeling of responsibility, and that the Public Health Service intended to pursue actively some investigation along this line. But that does not show up in this reply.

Dr. FISHER. That, I believe, sir, is covered in brief form in the second paragraph from the end, at the bottom of page 1 and the top of page 2, stating that research on the subject is underway in the Department.

Mr. SCHENCK. Yes. The sentence there is:

> In addition this Department, as well as commercial and other agencies, is supporting research aimed at the elimination or major reduction of unburned hydrocarbons in motor vehicle exhaust.

"Is supporting research," the statement says; but is it actively supporting research? Is it really going actively after the problem? That is not clear and I want some definite assurance.

Dr. FISHER. We are supporting research in three general methods: through research grants to investigators, which go into more basic

research; by contractual research with universities, other Federal agencies; and by direct operation in our Taft Engineering Center laboratories.

Mr. SCHENCK. Mr. Chairman, the Surgeon General expressed very deep and grave and great concern here last year about the incidence of so-called Asiatic flu, and went to great lengths to alert the country to recommend all kinds of inoculations for what he thought would then become an epidemic. We apparently have an epidemic of traveling air-pollution machinery, and the Department says it may take 10 years before any definite conclusions can be reached. Certainly that does not indicate the Department is giving the attention to this matter that it rightfully deserves.

Dr. FISHER. On February 21 we had concluded the third or fourth advisory committee on air pollution to the Surgeon General of the Public Health Service. At that meeting were very many of the witnesses you have had before you today. I am sure Dr. Burney is fully aware of the extent of the problem and of the needs.

This program, sir, is fairly new.

We have been in business now just about 2½ years, starting from almost nothing. It has taken some considerable time to even describe the problem in broad terms. I think we are beginning to get a very clear picture now of national problems as they exist, and the areas of greatest need of intensive study and development.

That was manifest at this last advisory committee meeting.

Mr. SCHENK. Mr. Chairman, I suggest that it has been commented on a number of times that the best way to delay the action of something was to refer it to a conference, a committee, a group, or something else for study. It would seem to me that that is one thing that is being done here. It would be very easy to spend months on trying to draw up beautiful charts to delineate the program, and to describe a problem. But in the meantime, we ought to be doing something to solve the problem. Certainly the Department of Public Health ought to know something, too, by this time, about the tolerances that the human body can stand in breathing polluted air.

As I understand, and I am certainly not a scientist or an engineer, as I understand life, it cannot be kept going without two things, one being air and the other being water, and in the absence of either one there is no life.

Certainly, with that very fundamental need for the furtherance of life, it would seem to me that the Public Health Department ought to be a little more aware and concerned and working on this problem.

I do not mean to be too rough, but at the same time I do not want to have all the reasons why it can't be done. I would like to see some reasons why it can be done. We have had some very good answers here today.

That is all I have, Mr. Chairman.

Mr. LOSER. Mr. Bush?

Mr. BUSH. I do not have any questions, Mr. Chairman.

Mr. LOSER. Doctor, I believe you are the chief of the medical program with reference to air pollution?

Dr. FISHER. Yes, sir.

Mr. LOSER. How long have been you in that position?

Dr. FISHER. Since the beginning; since July 1, 1955.

Mr. LOSER. Do you have any papers or any recommendations, any reports made to your chief or the head of your Department, that you would like to have placed in the record here?

Dr. FISHER. I think the recommendations are covered in the Department letter, sir—in the letter from the Department.

Mr. LOSER. This is a letter from the Department of Health, Education, and Welfare, dated February 19, 1958. Has there been any thing prior to this letter of February 19, this year, in connection with air-pollution, medical programs?

Dr. FISHER. Yes. We have a fairly extensive program, both the engineering and the medical program in detail. If you would like, I would be most happy to supply summary information on that.

Mr. LOSER. Without objection, that may be supplied for the record.

Dr. FISHER. We will be most happy to supply that, sir.

(The information referred to follows:)

HOW TO RECOGNIZE UNNECESSARY VEHICLE EXHAUST SMOKE EMISSIONS

By AMA—Special group on exhaust smoke

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W. M. Wiese, research staff, GMC.

For many years research organizations within the automotive industry have been instrumental in the reduction of exhaust smoke emissions from internal combustion engines. Research programs directed toward better combustion processes, better lubrication, and better structural design have resulted in more efficient engines which produce a minimum amount of exhaust smoke under normal operating conditions. The automotive industry, however, recognizes that normal wear, the malfunction of accessory equipment, the lack of proper maintenance, or improper operating practices can cause a properly designed engine to produce undesirable exhaust smoke emissions. As a result, the vehicle combustion products subcommittee of the Automobile Manufacturers Association has been engaged in extensive cooperative research covering all types of exhaust emission.

The problem of visible type exhaust emission was emphasized, late in the summer of 1955, when the city of Detroit proposed a new ordinance concerning motor-vehicle exhaust smoke emission. The proposed ordinance defined unreasonable smoke or vapor emission to be any emission which is visible for a distance of 36 inches or more beyond the end of the exhaust pipe of a vehicle. Even though this proposal appeared to be explicit, questions immediately arose as to the technical and legal difficulties that would be encountered in the enforcement of this type of ordinance. Realizing the importance of this problem to the automotive industry and to other large municipalities over the Nation, as well as to Detroit and local automobile, truck, and bus owners and operators, the Automobile Manufacturers Association (AMA) became interested in the Detroit exhaust smoke emission ordinance.

On September 21, 1955, the AMA extended an offer from the automotive industry to assist in establishing facts needed to formulate a workable exhaust smoke ordinance and enforcement program for the city of Detroit. A special group on exhaust smoke was formed under the auspices of the AMA vehicle combustion products subcommittee consisting of engineering representatives from major automobile, truck, and engine manufacturers. This group, in cooperation with the Detroit Smoke Abatement Bureau and the Detroit Police Department, immediately began work on the exhaust smoke problem.

OBJECTIVES

The first objective in the program was to provide technical assistance in

formulating a new vehicular exhaust ordinance. This included a review of existing and proposed exhaust emission ordinances. Discussions between the industry representatives, smoke abatement officials, and law enforcement personnel established that specific legal definitions, such as the length of duration of visible exhaust emissions, do not adequately recognize that different types of vehicles have widely different exhaust problems and, therefore, require different standards for judgment. Because of this, a satisfactory ordinance must include terms sufficiently broad to describe unnecessary emissions from all types of vehicles.

Considering the above factors, it was apparent that additional material was needed to be used as a guide to enforcement personnel when dealing with a specific type of vehicle. It was decided that an effective enforcement program could be built around two training materials: (1) an educational film designed to acquaint the observer with the smoke emission problem, and (2) a small pocket guide to act as a yardstick in judging exhaust smoke. Production of a training film and pocket guide that were technically sound, yet simple and practical, became the final objective of the group.

ACCOMPLISHMENTS

Exhaust smoke ordinance

Members of the special group on exhaust smoke and legal specialists from AMA assisted personnel from the Detroit Smoke Abatement Bureau and the Detroit corporation counsel's office in preparing a new vehicular exhaust ordinance which was adopted by the Detroit Common Council on April 10, 1956. The new ordinance reads.

"No person, firm, or corporation shall operate or cause to be operated upon any street, highway, or other public place a motor vehicle, while stationary or moving, which emits from any source any unreasonable, excessive, or unnecessary smoke, obnoxious or noxious gases, or vapor."

The ordinance is written in very broad terms to adequately describe emissions from all types of vehicles.

Training film

The major purpose of the training film is to present the exhaust smoke problem to enforcement personnel. The film shows typical exhaust smoke emissions from the most common vehicle types, indicates broadly which emissions are bad, and points out misleading conditions during which vehicles may appear to have excessive emission.

The task was begun by collecting all of the available smoke-emission film that the participating companies had in their files. From these films and from on-the-spot observations of smoking vehicles operating on the city streets, it became apparent that many factors, such as background, lighting, wind direction and velocity, camera position, exhaust-pipe position, engine type, etc., would need to be considered in making the film. As a result, the group decided to make a preliminary version of the film in which various photographic techniques could be explored. Each participating company took color motion pictures of emissions from different types of vehicles against various backgrounds, and under different operating conditions. In order to obtain varying degrees of emission from a given vehicle, it was sometimes necessary to simulate smoking conditions. The resulting films were screened and those best approaching typical operating conditions were combined into a preliminary training film. The film included examples of necessary and unnecessary smoke emission from various types of vehicles. This preliminary version of the training film was shown to the Air Pollution Control Association during their annual meeting at Buffalo, N. Y., on May 24, 1956.[1]

As a result of favorable response from both city and industry officials, as well as the APCA, the final professional version of the film was prepared. The final version of the training film, No Smoking, is about 10 minutes in length and includes illustrations of necessary and unnecessary exhaust smoke emissions from passenger cars, gasoline-powered trucks, diesel-powered trucks with both horizontal and vertical exhausts, gasoline-powered coaches, and diesel-powered coaches. As explained in the film narrative, unnecessary visible emissions from gasoline-powered vehicles are usually caused by excessive oil consumption

[1] Bowditch, F. W., Report on Automobile Industry Phase of Cooperative Work on Excessive and Unnecessary Vehicle Exhaust Smoke Emissions, Air Pollution Control Association, proceedings, 49th annual meeting, May 20–24, 1956, Buffalo, N. Y.

resulting from worn piston rings, cylinder liners, and valve guides. Similar emissions from diesel engines generally result from overfueling that may be caused by incorrect injector adjustment or bruned injector tips, restrictions in the inlet air system, overloading the engine, substandard fuel, cold operation, or mechanical deterioration of the engine. Misleading conditions, such as the emission of water vapor during cold operation, and the formation of dust clouds resembling exhaust emission, are illustrated. The film is simple, direct, and can be easily understood by nontechnical personnel.

Pocket guide

In order to identify vehicles that are smoking unnecessarily, a small pocket guide was developed. The guide includes examples of unnecessary smoke emission from common types of vehicles. A copy of the Motor Vehicle Exhaust Smoke Guide is attached to this report.

Color photographs were made showing various degrees of exhaust smoke emission for passenger cars, gasoline-powered trucks, diesel-powered trucks having both vertical and horizontal exhausts, gasoline-powered coaches, and diesel-powered coaches. Smoking conditions were simulated in order to maintain better control of background color, smoke intensity, wind direction and velocity, lighting, etc. From among the many photographs showing various degrees of emission, industry representatives selected a single photograph for each vehicle type which they felt was representative of marginally unnecessary exhaust emission. These photographs were then assempled in pamphlet form for use as a guide in recognizing unnecessary smoking conditions. For a given vehicle type, if smoke emission is equal to or greater than that shown in the appropriate photograph, it is considered unnecessary. Certain operating conditions produce emissions which may be misleading to the observer. Among these are: water-vapor formation during cold-weather operation, emissions during diesel-engine warmup, emissions of short duration during gear shifting, and dusts clouds formed at the rear of a moving vehicle. These conditions are discussed on the back page of the pocket guide.

The pocket guide was prepared in cooperation with the Detroit Smoke Abatement Bureau and the Research and Planning Group of the Detroit Police Department. The guide is copyrighted by the AMA because of the precision required to accurately reproduce color photographs of exhaust smoke emissions.

Prior to final issuance of the pocket guide, it was reviewed by various groups and associations concerned with the control of vehicle exhaust emission. These groups included:

AMA Vehicle Regulation Subcommittee.
AMA Vehicle Combustion Products Subcommittee.
AMA Truck Technical Committee.
AMA Service Managers Committee.
Air Pollution Control Association.
Michigan Trucking Association.
Michigan Motor Bus Association.
Detroit Police Department.
Detroit Smoke Abatement Bureau.
Detroit Traffic Court Judges and Referees.
Cincinnati Smoke Abatement Officials.
Cincinnati Transit Company.

The reaction of each of these groups was favorable. The general reaction was that the pocket guide would be of great assistance in enforcing the exhaust smoke ordinance in a practical manner. Several of these groups felt that the pocket guide would also serve as a guide to maintenance people in deciding when service is required on vehicles.

CURRENT STATUS

The Detroit Police Department is currently using both the training film and the pocket guide in enforcing the vehicle exhaust smoke ordinance. Each enforcing officer is given the opportunity to view the film to become acquainted with the nature of the vehicle-smoke problems. He is then issued a copy of the pocket guide to use in the field in identifying excessive smokers.

Copies of the training film, No Smoking, are available through AMA at a cost of $47.50 each. Copies of the Motor Vehicle Exhaust Smoke Guide are also available through the AMA. The exact cost has not yet been determined.

ANNUAL MEETING PAPER NO. 55-19

APCA

AIR POLLUTION CONTROL ASSOCIATION,

4400 Fifth Ave., Pittsburgh 13, Pa.

TITLE: THE COMPOSITION OF EXHAUST GASES FROM DIESEL, GASOLINE, AND PROPANE POWERED MOTOR COACHES.

Detroit, Michigan
May 22 - 26, 1955

AUTHORS: Martin A. Elliott
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THE COMPOSITION OF EXHAUST GASES FROM DIESEL, GASOLINE, AND PROPANE POWERED MOTOR COACHES

INTRODUCTION

Air pollution studies have shown that certain constituents in exhaust gases from automotive vehicles may react in the atmosphere to form smog-type pollutants. As a result, considerable effort has been made to determine the composition of automotive vehicle exhaust gases with particular emphasis on trace constituents such as hydrocarbons and oxides of nitrogen. Most of this experimental work has been conducted on passenger cars with little similar work being done on motor coaches. However, there is considerable interest in the composition of motor coach exhaust gases on the part of manufacturers and operators. Their interest is caused by a desire to manufacture and operate equipment which contributes least to air pollution.

This report compares motor coaches powered by 2-cycle Diesel, gasoline, and propane engines with respect to their emission of objectionable exhaust gas constituents. The tests were made under road operating conditions typical of normal coach operation.

CONSTITUENTS OF EXHAUST GASES FROM INTERNAL COMBUSTION ENGINES

The exhaust gases from internal combustion engines are complex mixtures consisting principally of the products of complete combustion with small amounts of the oxidation products of sulfur and nitrogen, along with compounds derived from the fuel and lubricant. The major and minor constituents are listed in Table I.

In relation to air pollution, exhaust gas constituents may be divided into three classifications:

1. Harmful to health
2. Objectionable
3. Potentially objectionable

Certain constituents may be placed in more than one of the above classifications.

TABLE I

Constituents of Internal Combustion Engine Exhaust Gases

Major Constituents (greater than 1%)	Minor Constituents (less than 1%)
Water, H_2O	Oxides of Sulfur, SO_2, SO_3
Carbon Dioxide, CO_2	Oxides of Nitrogen, NO, NO_2
Nitrogen, N_2	Aldehydes, HCHO, etc.
Oxygen, O_2	Organic Acids, HCOOH, etc.
Carbon Monoxide, CO*	Alcohols, CH_3OH, etc.
Hydrogen, H_2*	Hydrocarbons, C_nH_m
	Carbon Monoxide, CO**
	Hydrogen, H_2**
	Smoke

* Spark ignition engine
** Diesel engine

Some typical harmful exhaust gas constituents and their permissible concentration for a continuous 8-hour exposure are shown in Table II.

TABLE II

Threshold Limits for Continuous 8-Hour Exposure*

Constituent	Per Cent by Volume	Parts Per Million by Volume
Carbon Dioxide	0.5	5000
Carbon Monoxide	.010	100
Sulfur Oxides (SO_2)	.0010	10
Formaldehyde	.0005	5
Nitrogen Oxides	.0005	5

*Adopted by the American Conference of Governmental Industrial Hygienists, April 24, 1954.

The objectionable constituents are either odorous or irritating and include aldehydes and other compounds resulting from the partial oxidation or reaction of the fuel. The latter compounds may appear as smoke.

The potentially objectionable constituents are those materials which may react directly or indirectly to form irritating and lachrymating pollutants.

Since it has been shown that certain hydrocarbons may react in the presence of oxides of nitrogen and ozone to form eye and nose irritants, hydrocarbons must be considered in this classification.

The subsequent discussion is limited to carbon monoxide, oxides of nitrogen, formaldehyde, and hydrocarbons since these compounds are believed to be of greatest importance to air pollution.

EXPERIMENTAL PROCEDURE

Selection of Coaches

Three coaches of each engine type, 2-cycle Diesel, gasoline, and propane, were selected from the Chicago Transit Authority's operating fleet. The physical size and passenger capacity of the different model coaches were about the same. The selection of the individual coaches was made on the basis of the fuel and lubricating oil consumption being close to the average for their type. No engine adjustments were made prior to the tests. Descriptive information on the three types of coaches is shown in Table III.

TABLE III

Description of Coaches Tested

Coach Designation	Passenger Capacity	Engine Type	Compression Ratio of Engine	Engine Displacement, In^3	Range of Miles Since Last Major Overhaul
A, B, C	45	Diesel (2-cycle)	16.0	426	126,000 to 217,000
D, E, F	44	Gasoline	6.0	707	208,000 to 217,000
G, H, I	50	Propane	9.5	477	*

*These coaches were new and had operated 21,000 to 27,000 miles without overhaul.

Operating Conditions

Each coach was tested under idling conditions and while operating on city streets under accelerating, cruising, and decelerating conditions. The acceleration test was made at full throttle up a slight grade at speeds less than 15 miles per hour. The cruising test was made with

the coach operating in direct drive on a level street at 30 miles per hour. The decelerating test was made with the coach operating in direct drive on a slight down grade at 25 - 30 miles per hour.

Sampling Procedures

Two samples of the exhaust gases were collected in evacuated 250 ml sampling tubes for analysis by mass spectrometer and by Orsat apparatus. Duplicate samples for determination of the concentration of total oxides of nitrogen and formaldehyde were collected in evacuated 500 ml bottles containing suitable absorbing solutions.

The exhaust gas was sampled upstream from the muffler and as near the exhaust manifold as possible. The exhaust gas flowed from the sampling point through copper tubing to the sampling manifold. (See Figure 1.) The sampling line to the manifold was continuously purged by the normal flow of exhaust gas resulting from the back pressure in the exhaust system. When samples were taken, the discharge end of the manifold was closed to prevent contamination of the samples with air.

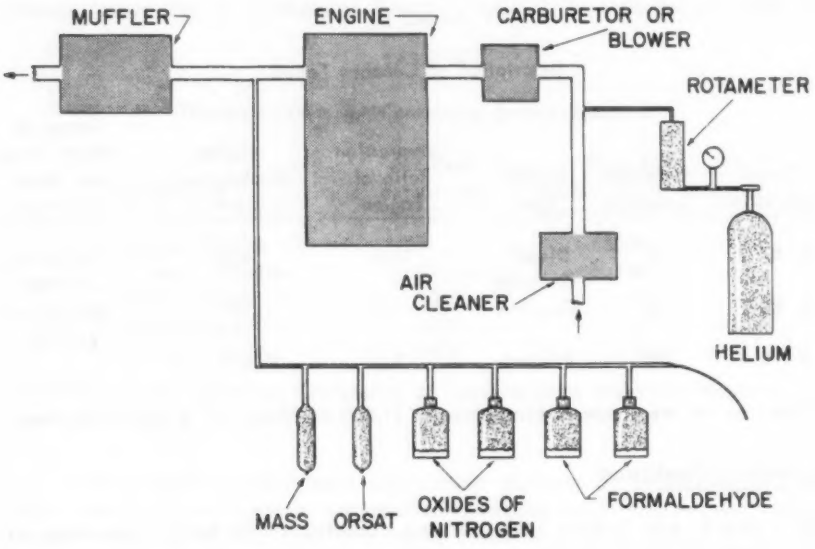

Figure 1

Samples were taken when the coach reached the desired operating condition. Approximately two to five seconds were required to fill the evacuated bottles.

Analytical Procedures

Samples were analyzed by the mass spectrometer primarily to determine the concentration of hydrocarbons, although the concentrations of the major constituents were reported. Carbon dioxide, oxygen, and carbon monoxide were also determined by Orsat analysis. It is believed that the Orsat determinations of these three constituents, particularly carbon monoxide, are the more reliable and consequently were used in calculations.

Formaldehyde was determined by a modification of the phenylhydrazine-ferricyanide method described by Kersey, Maddock, and Johnson.[1] The total oxides of nitrogen (except N_2O) were determined by the phenol disulfonic acid method described by Beatty, Berger, and Schrenk.[2] Both are relatively sensitive colorimetric tests.

Exhaust Gas Flow Rate Measurement

In order to calculate the total quantity of any exhaust gas constituent discharged per unit time, it is necessary to know the exhaust gas flow rate as well as the concentration of the constituent. The direct measurement of the exhaust gas flow rate of a moving vehicle is difficult. Accordingly, it seemed advisable to use a dilution metering technique. Helium was admitted to the air intake of the engine through a rotameter at a known rate just prior to and during the sampling period. (See Figure 1.) The concentration of helium in the exhaust was determined by mass spectrometric analysis. Thus it was possible to calculate the exhaust gas flow rate. Previous laboratory studies indicated that the addition of as much as 3% of helium had little or no effect on engine performance.

EXPERIMENTAL RESULTS

The experimental results for the three coaches of each type have been averaged and, for simplicity, only these averages will be considered in the following discussion. Complete experimental data for each coach are presented at the end of the report in Tables VI, VII, VIII and IX.

1. The Analyst, 65, 203, (1940).
2. U. S. Bureau of Mines R.I. 3687, (1943).

For each of the four constituents, both the concentration in the exhaust gas and the total rate of emission are presented. Exhaust gas composition is useful for comparing the concentration of the harmful constituents with the permissible toxic limits. However, in relation to air pollution, the total quantity of an exhaust gas constituent discharged per unit time is most significant. If the total quantities of an exhaust gas constituent are known, comparisons of emission from vehicles in comparable service but powered by different types of engines can be made.

Carbon Monoxide

The concentration of carbon monoxide observed in the various tests is shown in Figure 2. Under all driving conditions the exhaust gases from Diesel engines contained less than 0.1 per cent carbon monoxide, whereas the carbon monoxide concentrations in the exhausts of the carbureted engines ranged from 1.5 to 12 per cent. The reason for this difference is the well-known fact that carbureted engines generally operate with a

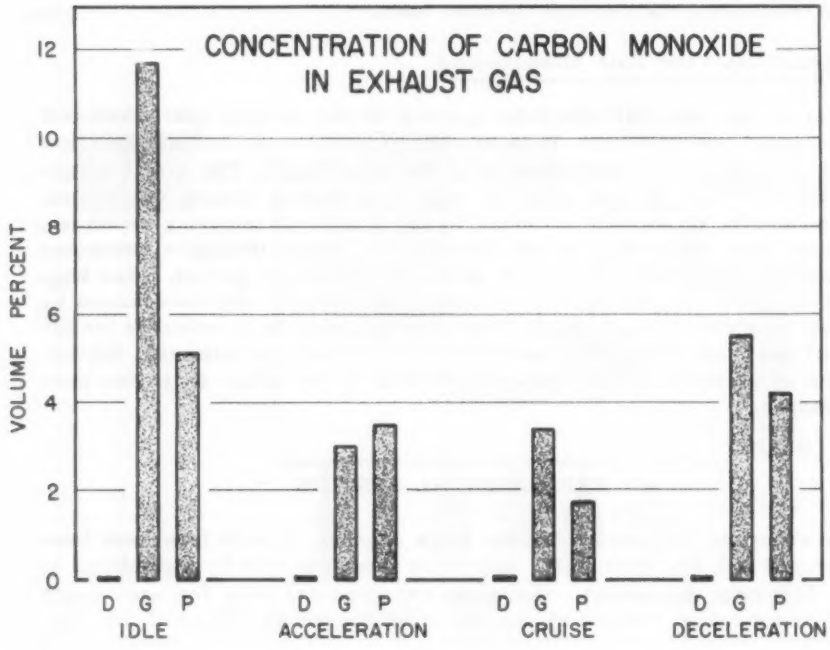

Figure 2

deficiency of air whereas Diesel engines always operate with a substantial excess of air. In these tests the concentration of carbon monoxide in the exhaust from the propane coaches was generally less than that from the gasoline coaches. Since the vehicles were tested with the carburetor adjustments "as received," no generalizations should be made from these tests concerning the relative merits of the gasoline and propane coaches.

The concentration of an exhaust gas constituent alone is not indicative of the contribution of the constituent to the over-all air pollution problem because of the wide variations in exhaust gas flow rate with different engine types and different operating conditions. What is important is the amount of the constituent discharged per unit time. Figure 3 shows the carbon monoxide emission expressed in standard cubic feet, at 60°F and 1 atmosphere, per hour (abbreviated SCFH). The average emission of carbon monoxide for the Diesel coaches was less than 15 SCFH under all driving conditions whereas the amount discharged by the carbureted engines ranged from about 40 to 290 SCFH.

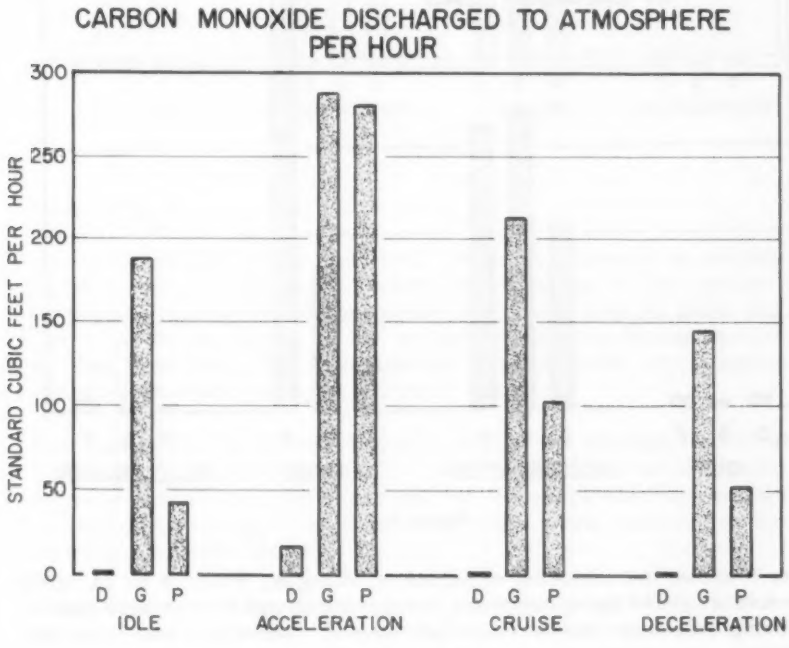

Figure 3

Oxides of Nitrogen

The concentrations of oxides of nitrogen observed in these tests for the various types of coaches and driving conditions are illustrated in Figure 4. During cruise and acceleration, average oxides of nitrogen concentrations ranged from about 200 to 2000 parts per million but at idle and deceleration the concentrations were below 60 parts per million. These observations are consistent with thermodynamic predictions that higher combustion chamber temperatures favor the formation of oxides of nitrogen.

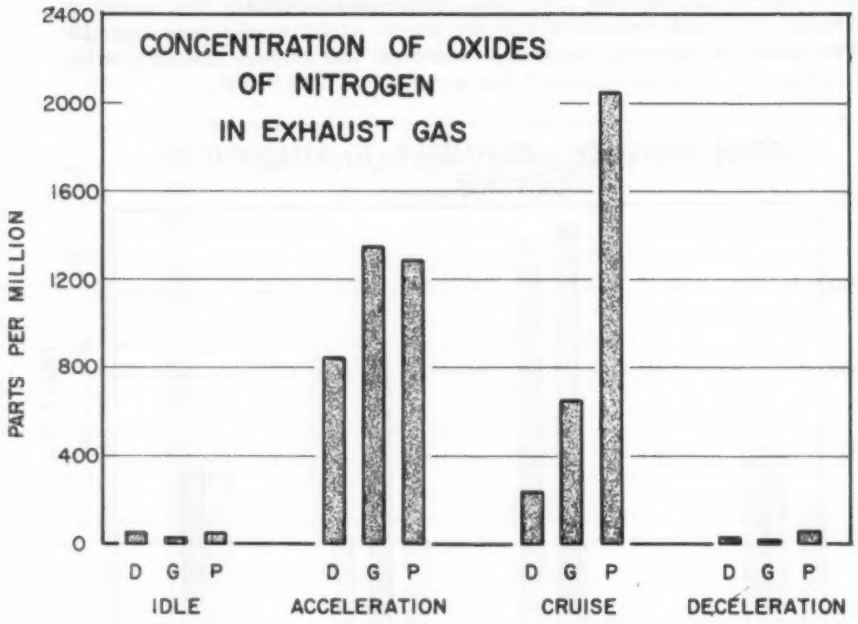

Figure 4

Figure 5 shows the emission of oxides of nitrogen. From 4 to 24 SCFH were discharged to the atmosphere during cruise and acceleration whereas during idle and deceleration the amount discharged was less than 0.5 SCFH. In these tests no one engine type consistently discharged more or less oxides of nitrogen than the other two types.

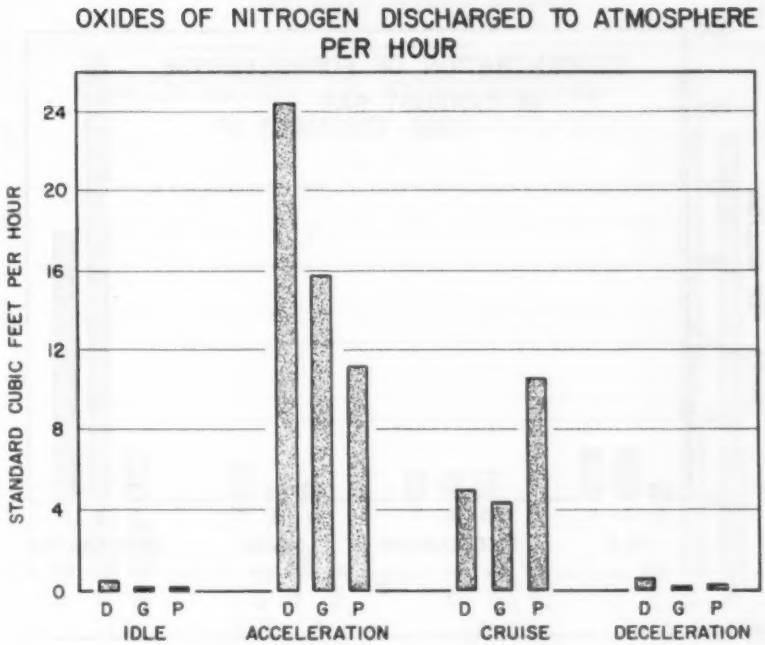

Figure 5

Formaldehyde

The concentration of formaldehyde shown in Figure 6 is an indication of the amount of partially oxidized hydrocarbon in the exhaust. The average formaldehyde concentrations were less than 30 parts per million with the exception of the carbureted engines during deceleration. At that condition, the formaldehyde concentrations were appreciably higher, up to 300 parts per million.

The amount of formaldehyde discharged to the atmosphere, illustrated in Figure 7, ranged from 0.025 to 0.75 SCFH. The deceleration driving condition was the most critical for the carbureted engines whereas for the Diesel engines high emission rates were observed at both acceleration and deceleration.

Aldehydes have been used as a measure of the odor intensity of exhaust gases from a particular type of engine. It should not be inferred from this that aldehydes, especially formaldehyde, can be used as a criterion

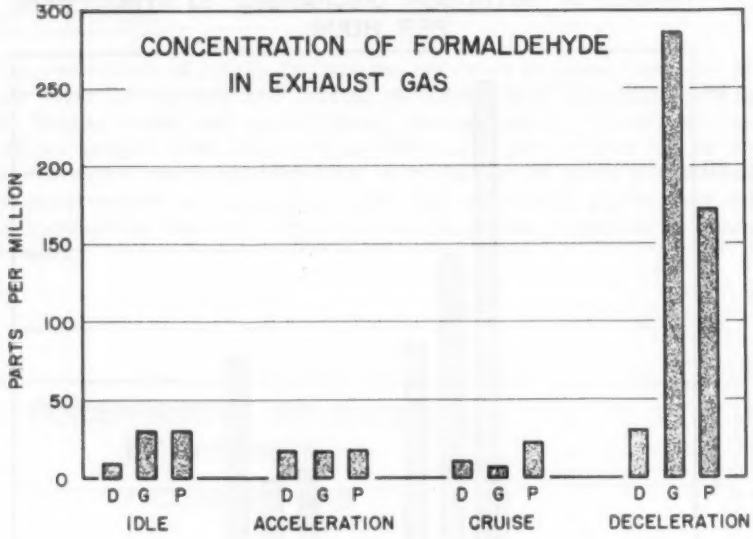

Figure 6

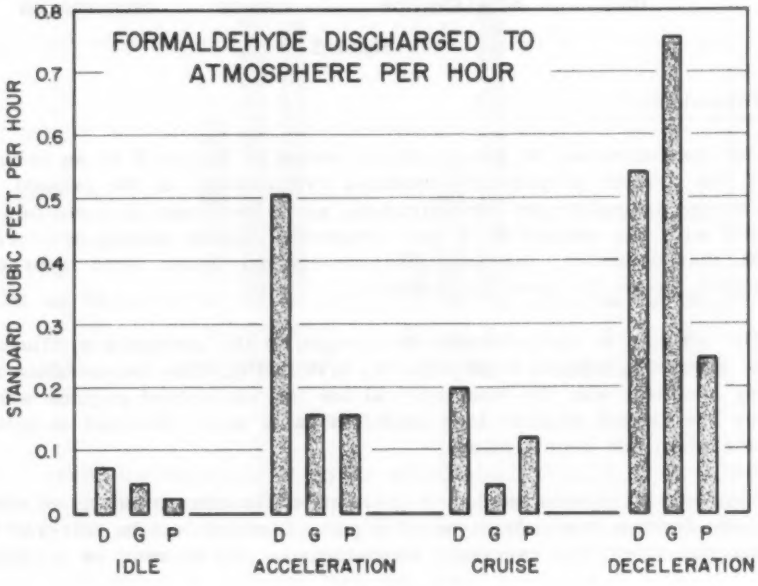

Figure 7

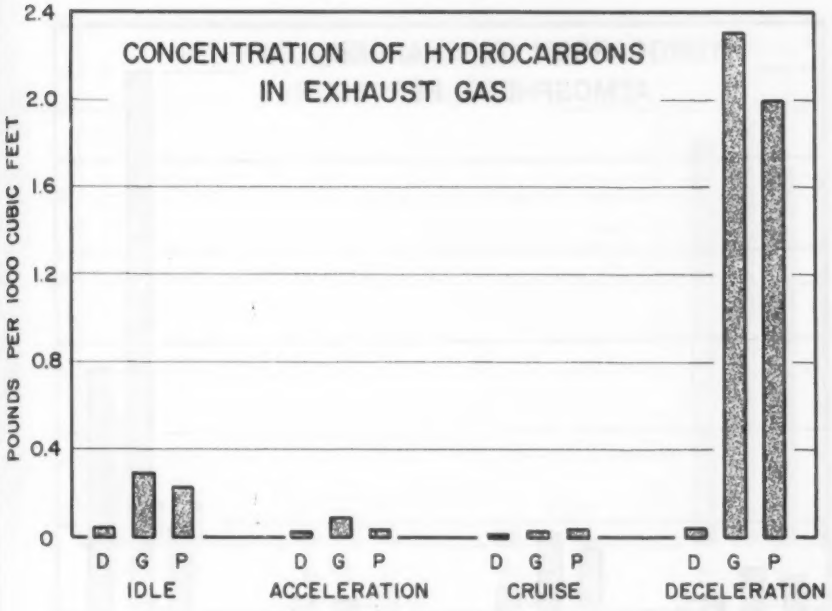

Figure 8

for the odor intensity of exhaust gases from different types of engines burning different fuels. A discussion of this subject is beyond the scope of this paper but this problem is being actively investigated at this Laboratory.

Hydrocarbons

In the previous discussion the concentration of the exhaust gas constituents has been expressed as per cent or parts per million by volume. For hydrocarbons, such a method of expressing concentration is not satisfactory for comparative purposes because the average molecular weight of the hydrocarbons in exhaust gas is not constant. A more satisfactory basis is to express the hydrocarbon concentration is terms of weight per unit volume of exhaust. Such data are illustrated in Figure 8. The observed hydrocarbon concentrations ranged from less than 0.04 pounds per thousand cubic feet of exhaust during cruise to more than 2.3 pounds per thousand cubic feet of exhaust during deceleration. The similarity of the data for the carbureted engines in Figures 6 and 8 suggests that the engine conditions giving rise to high hydrocarbon concentrations also favor the formation of formaldehyde.

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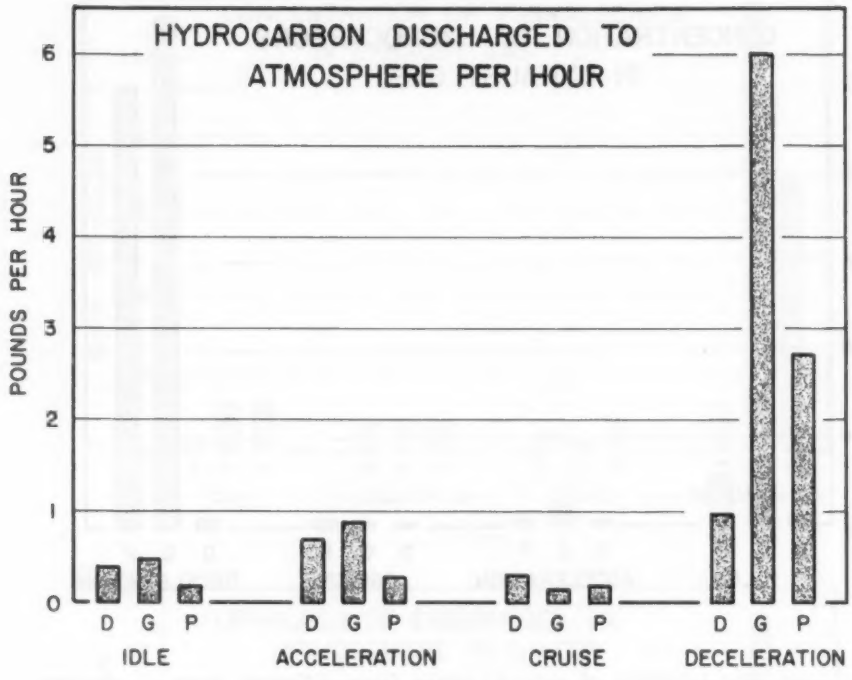

Figure 9

Of more importance to the over-all air pollution problem is the total amount of hydrocarbon discharged to the atmosphere per unit time. A comparison of the three different engine types at each driving condition is shown in Figure 9. At deceleration the carbureted engines discharged from 2.7 to 6 pounds per hour compared to 1 pound per hour for the Diesel engines. For the other driving conditions there was little difference among the various engine types with emission rates ranging from 0.2 to 0.9 pounds per hour.

The weight per cent of the supplied fuel present in the exhaust gases as C_1 to C_8 hydrocarbons is one indication of the combustion efficiency to the engine. The data in Figure 10 show that for all types of engines less than 2 per cent of the supplied fuel is wasted during cruise or acceleration whereas more than 34 per cent of the supplied fuel is wasted during deceleration. With the exception of the Diesel at idle, the various types of engines appear quite similar on this basis. However, the data in Figure 9 show that the amount of hydrocarbons found in the exhaust of

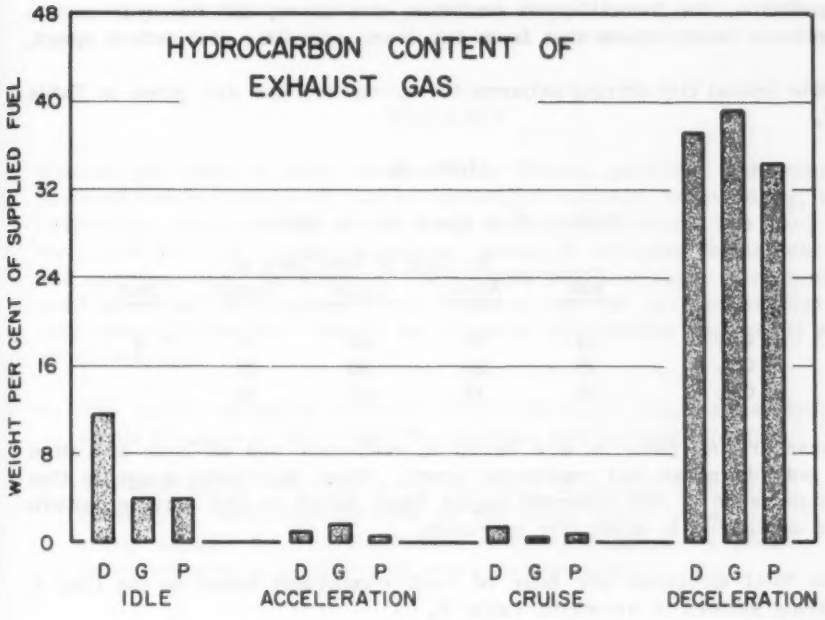

Figure 10

Diesel engines under decelerating conditions was smaller than that in carbureted engines and comparable at idle.

DISCUSSION

Driving condition has a marked effect on the emission rate of all constituents. Furthermore, the relative order of the coaches was not the same at all driving conditions, except for carbon monoxide emission. Therefore, for the other constituents, it is necessary to take into account the time spent at each driving condition when comparing the coaches.

An indication of the importance of driving condition may be obtained from the following example. Consider two identical gasoline coaches operating either (a) at constant speed corresponding to the 30 mph cruise condition, or (b) alternately accelerating and decelerating. While the carbon monoxide emission for the two coaches would be about the same, the emission of oxides of nitrogen from the cycling coach would

be double, the formaldehyde emission nine times, and the hydrocarbon emission twenty times that from the coach operating at constant speed.

Some typical city driving patterns for motor coaches are given in Table IV.

TABLE IV

Typical Motor Coach Driving Patterns

	Per Cent of Time Spent at				
	Idle	Accel.	Cruise	Decel.	Stop
City A	35	15	30	15	5
City B	25	20	30	25	
City C	30	15	40	15	

These driving patterns are based on rush-hour and off-hour operation in both downtown and residential areas. Their similarity suggests that comparisons of the different engine types based on one driving pattern are applicable to most city operation.

The total emission per hour of each constituent based on the City A driving pattern is shown in Table V.

TABLE V

Total Hourly Emission Based on City A Driving Pattern

	Carbon Monoxide SCFH	Oxides of Nitrogen SCFH	Formaldehyde SCFH	Hydrocarbons lb/hr
Diesel	2	5.4	0.24	0.47
Gasoline	194	3.8	0.17	1.24
Propane	96	4.9	0.11	0.57

These data show that the Diesel coaches produced substantially less carbon monoxide than either the propane or gasoline coaches. With respect to the other constituents, no such large differences were observed, and the relative rank of the different coaches was not consistent. For example, the gasoline coaches produced the least quantity of oxides of nitrogen; the propane coaches, the least formaldehyde; and the Diesel and propane coaches, the least hydrocarbons. At the other extreme, the propane and Diesel coaches produced the greatest quantity of oxides of nitrogen; the Diesel coaches, the most formaldehyde; and the gasoline coaches, the most hydrocarbons.

The Diesel coaches were markedly superior with respect to carbon monoxide emission. There was comparatively little difference between coach types in the over-all emission of the other constituents.

SUMMARY

Exhaust gas samples were obtained from Diesel, gasoline, and propane powered motor coaches of similar passenger capacity under idling, accelerating, cruising, and decelerating driving conditions. The samples were analyzed for carbon monoxide, oxides of nitrogen, formaldehyde, and hydrocarbons. In addition, the exhaust gas flow rates were measured to permit calculation of the emission rate for each constituent at each driving condition. Based on a typical city driving pattern, it was concluded that:

1. The carbon monoxide emission from the Diesel coaches was only a small fraction of that from the gasoline and propane coaches.

2. The differences observed in the emission of oxides of nitrogen, formaldehyde, and hydrocarbons by the three coach types were relatively small. No one coach type discharged either the greatest or least amounts of all three of these constituents.

ACKNOWLEDGMENT

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3. Messrs. J. T. Wentworth and W. A. Daniel for their assistance in running the tests.

4. The members of the Fuels and Lubricants Department, General Motors Research Laboratories, for their suggestions and criticisms during the preparation of the manuscript.

TABLE VI

Summary of Experimental Results at Idle

Vehicle	Engine Type	Exhaust Flow SCFM	Carbon Monoxide		Hydrocarbons				Oxides of Nitrogen		Formaldehyde	
			vol %	SCFH	vol %	lbs/SCF·10^6	% UBF	lbs/hr	P.P.M.	SCFH	P.P.M.	SCFH
A	Diesel	98	0.0	0	0.047	61.6	14.4	0.363	60	0.353	6	0.035
B	(2-cycle)	95	0.0	0	0.017	23.1	5.4	0.132	50	0.285	4	0.023
C		159	0.0	0	0.053	66.4	15.4	0.633	68	0.648	17	0.162
	Average		0.0	0	0.039	50.4	11.7	0.376	59	0.429	9	0.073
D	Gasoline	27	13.85	225	0.983	602	7.7	0.975	45	0.074	72	0.117
E		25	11.15	167	0.304	152	2.2	0.228	15	0.023	12	0.018
F		29	10.1	176	0.163	124	1.8	0.215	38	0.066	5	0.009
	Average		11.7	189	0.483	293	3.9	0.473	33	0.054	30	0.048
G	Propane	15	3.65	32.8	0.176	183	3.5	0.164	90	0.081	24	0.022
H		13	8.0	62.3	0.359	281	4.6	0.219	25	0.019	35	0.027
I		15	3.75	33.7	0.189	205	3.7	0.184	27	0.024	30	0.027
	Average		5.1	43.0	0.241	223	3.9	0.189	47	0.041	30	0.025

TABLE VII

Summary of Experimental Results at Acceleration

Vehicle	Engine Type	Exhaust Flow SCFM	Carbon Monoxide		Hydrocarbons				Oxides of Nitrogen		Formaldehyde	
			vol %	SCFH	vol %	lbs/SCF·10^6	% UBF	lbs/hr	P.P.M.	SCFH	P.P.M.	SCFH
A	Diesel	447	0.0	0	0.018	20.5	0.8	0.550	827	22.2	7	0.188
B	(2-cycle)	461	0.1	27.7	0.023	30.1	1.2	0.833	863	23.9	6	0.166
C		529	0.05	15.9	0.021	21.3	0.9	0.677	856	27.2	37	1.173
	Average		0.05	14.5	0.021	24.0	1.0	0.683	849	24.4	17	0.509
D	Gasoline	129*	2.8	217	0.202	174	3.0	1.345	1430	11.1	28	0.217
E		271	2.2	357	0.051	66.2	1.2	1.08	1940	31.5	13	0.211
F		123*	3.9	288	0.036	32.5	0.6	0.240	670	4.9	6	0.044
	Average		3.0	287	0.096	90.9	1.6	0.888	1347	15.8	16	0.157
G	Propane	165	2.7	267	0.024	21.6	0.4	0.208	2215	21.9	25	0.247
H		112	3.05	205	0.040	38.6	0.7	0.260	1130	7.6	13	0.087
I		127	4.8	369	0.052	48.1	0.8	0.369	524	4.0	17	0.138
	Average		3.5	280	0.039	35.9	0.6	0.279	1290	11.2	18	0.157

* Not full throttle acceleration.

TABLE VIII

Summary of Experimental Results at Cruise

Vehicle	Engine Type	Exhaust Flow SCFM	Carbon Monoxide vol %	Carbon Monoxide SCFH	Hydrocarbons vol %	Hydrocarbons lbs/SCF·10^6	Hydrocarbons % UBF	Hydrocarbons lbs/hr	Oxides of Nitrogen P.P.M.	Oxides of Nitrogen SCFH	Formaldehyde P.P.M.	Formaldehyde SCFH
A	Diesel	395	0.0	0	0.013	20.2	1.3	0.478	310	7.35	4	0.095
B	(2-cycle)	279	0.0	0	0.000	0	0.0	0.000	224	3.73	19	0.318
C		360	0.0	0	0.015	19.6	2.2	0.423	178	3.85	9	0.195
	Average		0.0	0	0.009	13.3	1.2	0.300	237	4.98	11	0.203
D	Gasoline	93	5.1	285	0.045	36.1	0.6	0.202	314	1.76	1	0.005
E		114	2.35	161	-	-	-	-	740	5.06	15	0.096
F		117	2.7	189	0.018	12.5	0.2	0.088	906	6.36	6	0.042
	Average		3.4	212	0.032	24.3	0.4	0.145	653	4.39	7	0.048
G	Propane	85	0.85	43.3	0.037	51.9	1.0	0.264	3050	15.5	39	0.198
H		85	1.0	51.0	0.026	25.3	0.5	0.129	2150	10.4	15	0.077
I		105	3.4	214	0.037	30.5	0.5	0.192	956	6.0	14	0.094
	Average		1.75	103	0.033	35.9	0.7	0.195	2052	10.6	23	0.123

TABLE IX

Summary of Experimental Results at Deceleration

Vehicle	Engine Type	Exhaust Flow SCFM	Carbon Monoxide vol %	Carbon Monoxide SCFH	Hydrocarbons vol %	Hydrocarbons lbs/SCF·10^6	Hydrocarbons % UBF	Hydrocarbons lbs/hr	Oxides of Nitrogen P.P.M.	Oxides of Nitrogen SCFH	Formaldehyde P.P.M.	Formaldehyde SCFH
A	Diesel	350	0.0	0	0.061	95.2	72.7	2.00	40	0.840	7	0.147
B	(2-cycle)	238	0.0	0	0.000	0	0.0	0	42	0.600	10	0.143
C		318	0.0	0	0.038	45.7	38.7	0.87	9	0.171	70	1.335
	Average		0.0	0	0.033	43.6	37.1	0.96	30	0.537	29	0.541
D	Gasoline	46	4.8	132	2.641	4170	60.7	11.52	12	0.033	244	0.675
E		36	6.25	135	1.844	2110	39.7	4.51	12	0.026	303	0.658
F		50	5.5	165	0.541	637	17.4	1.92	30	0.090	312	0.936
	Average		5.5	144	1.675	2306	39.3	5.98	18	0.050	286	0.756
G	Propane	18	3.2	34.6	1.734	1895	34.6	2.05	77	0.083	154	0.167
H		18	5.3	57.2	2.475	2560	41.3	2.77	15	0.016	193	0.208
I		36	3.0	64.7	1.500	1530	27.1	3.31	77	0.166	169	0.365
	Average		4.2	52.2	1.903	1995	34.3	2.71	56	0.095	172	0.247

Control of Oxides of Nitrogen in Automobile Exhaust Gases—The Technical and Economic Aspects of One Approach

(By Ralph W. Bishop and George J. Nebel, research staff, General Motors Corp.)

(To be presented at the 22d annual meeting of the Industrial Hygiene Foundation, Pittsburgh, Pa., October 30–31, 1957)

Oxides of nitrogen in the atmosphere come from many sources, most of which involve the burning of solid, liquid, or gaseous fuels. Automobiles are reported to be one of the more important sources.

(1) For this reason, air pollution authorities have urged that some sort of control method or device be developed which will materially reduce the oxides of nitrogen found in automobile exhaust gases.

A significant reduction of oxides of nitrogen can be achieved by modifying carburetion. In carbureting a modern automobile, current practice is to vary the proportions of air and fuel supplied to the engine, depending upon how the automobile is driven. The principles underlying this practice are illustrated in figure 1 where engine power and fuel economy are shown as a function of air-fuel ratio.

Note in figure 1 that the air-fuel ratios for maximum power and for maximum economy do not coincide. Note further that the chemically correct or stoichiometric air-fuel ratio (about 15 to 1) is between these 2 ranges. Relatively rich mixtures, in the range of 12:1 air-fuel ratio, are needed to develop maximum power, whereas relatively lean mixtures, in the range of 16:1 air-fuel ratio, produce best fuel economy.

The carburetor engineer makes use of these relationships. Under some conditions of driving, when accelerating for example, carburetion is designed to supply rich maximum power mixtures. On the other hand, during steady speed driving, the maximum economy range is utilized.

The control method to be proposed in this paper is to provide rich air-fuel mixtures, in the maximum power range, at all driving conditions. The effectiveness and cost of this simple control method have been determined. This information, together with experimental work leading to the development of the method, are reported herein.

Effect of Operating Variables on Oxides of Nitrogen in a Single-Cylinder Engine

In order to develop a control method, it was necessary to determine how the concentration of oxides of nitrogen in engine exhaust gases varied with operating conditions. Accordingly, a series of tests were made using a single-cylinder laboratory test engine where operating variables could be easily and carefully controlled. The five variables investigated were air-fuel ratio, spark timing, manifold air pressure, compression ratio, and engine speed. Since the results have been reported previously (2), they will be reviewed here only briefly.

In the single-cylinder engine tests, and also in the automobile tests to be discussed later, concentrations of oxides of nitrogen were determined by the conventional phenol disulfonic acid (PDS) procedure. (3) In this procedure, all oxides of nitrogen except nitrous oxide are measured as equivalent nitrate, but the individual oxides are not identified. Accordingly, concentrations are reported as parts per million by volume of total oxides of nitrogen and the symbol NOx used on the graphs.

Air-fuel ratio

The effect of air-fuel ratio on the concentration of oxides of nitrogen is illustrated in figure 2. This characteristic relationship was observed at all operating conditions. The maximum concentration was always formed when the air-fuel ratio was 1 to 3 ratios leaner than the chemically correct or stoichiometric mixture, indicated by the S at the base of the graph. The minimum concentration was always formed at the rich limit.

Superimposed on figure 2 are the two bands shown in figure 1, the first indicating the air-fuel ratio range for maximum power and the other the air-fuel ratio range for maximum economy. Note that the highest concentrations of oxides of nitrogen occur within the maximum economy range. On the other hand, the lowest concentrations occur near the maximum power range.

Spark timing

The concentration of oxides of nitrogen increased as spark timing was advanced, but the effect was significant only when the air-fuel ratio was greater than stoichiometric. Typical experimental results are shown in figure 3. It is interesting to note that the concentration continued to increase as the spark was advanced beyond the maximum power setting, about 27° BTC for the operating conditions listed in figure 3.

Manifold air pressure

Increasing manifold air pressure, or engine load, increased the concentration of oxides of nitrogen. As with spark timing, the effect of manifold air pressure was greatest when the air-fuel ratio was greater than stoichiometric. Experimental results are shown in figure 4.

Compression ratio

Increasing compression ratio increased the concentration of oxides of nitrogen, but again the effect was significant only with lean mixtures. Figure 5 illustrates the effect of compression ratio.

Engine speed

The effect of engine speed is shown in figure 6. With rich mixtures, increasing speed favored the formation of oxides of nitrogen. With lean mixtures, the opposite effect was found. The maximum concentration observed at each speed decreased with engine speed.

Air-fuel ratio was by far the most important of the five variables investigated. Differences in concentration of oxides of nitrogen as great as one hundred fold were caused by air-fuel ratio changes.

EFFECT OF OPERATING VARIABLES IN A MULTICYLINDER AUTOMOTIVE ENGINE

The single-cylinder engine test results suggested that the concentration of oxides of nitrogen in automobile exhaust gases could be materially reduced by controlling air-fuel ratio and, perhaps, spark timing. The following tests were made to confirm these conclusions in a full scale automobile engine and, at the same time, to find out how operating variables affect fuel economy.

A late model automobile was equipped with a special carburetor, hydraulic spark timing control, and fuel metering aparatus. The characteristics of the carburetor were such that the air-fuel ratio could be varied from 10 : 1 to 25 : 1. Fuel economy and the concentration of oxides of nitrogen were measured simultaneously at road load or constant speed conditions. Three speeds and 3 spark settings—9 combinations in all—were investigated. The speeds were 30, 45, and 60 miles per hour. The spark settings were the manufacturer's recommended setting (different at each speed) and 10 and 20 crankangle degrees retarded from that value. At each combination of speed and spark setting, enough tests were made to cover the air-fuel range from about 11 : 1 to 20 : 1.

The results of the investigation are shown in figures 7, 8, and 9. At the top of each graph, fuel economy is plotted against air-fuel ratio with spark timing as a parameter. Corresponding concentrations of oxides of nitrogen are shown at the bottom of the graph. The effects of air-fuel ratio and spark timing on oxides of nitrogen determined in this study are similar to the trends observed in the single-cylinder test engine. The fact that higher concentrations of oxides of nitrogen were generally found at higher car speeds is believed due to differences in spark timing and is not an effect of engine speed per se.

Potential control methods—Fuel economy and other considerations

It is apparent from these data that there are five different ways to reduce oxides of nitrogen at part load conditions by altering carburetion and spark timing. The five methods are:

(1) Lean the mixture to an air-fuel ratio of 18 : 1 or greater.
(2) Richen the mixture to an air-fuel ratio of 12 : 1 or less.
(3) Retard the spark.
(4) Combine mixture leaning with spark retard.
(5) Combine mixture richening with spark retard.

Which of these is best from a fuel economy standpoint? The answer is not readily apparent from figures 7, 8, and 9. To show more clearly how the control methods rank with respect to fuel economy, figures 10, 11, and 12 were constructed.

In these graphs, the reduction in nitrogen oxide concentration is plotted against fuel economy loss, both expressed as percent. To do this, it was necessary to assume some sort of standard condition and calculate all percentage changes from that point. The standard condition was taken as 15 : 1 air-fuel ratio and manufacturer's spark setting, values which are typical for constant speed driving.

Five different curves are shown, one for each control method. The combination methods were calculated on the basis of a 10° spark retard.

It is clearly evident that mixture leaning is the most economical way to reduce oxides of nitrogen. Substantial reductions, of the order of 75 percent, are achieved with no significant change in fuel economy. However, part-throttle driveability, that is the ability of the car to maintain smooth operation free from surging or bucking, is seriously impaired when the air-fuel ratio is as lean as 18 : 1. For this reason, the method has little practical value.

The second most economical method is to combine mixture leaning with spark retard. Here again, however, part-throttle driveability is not entirly satisfactory, even though the air-fuel ratio is somewhat richer than when the spark is not retarded. This approach also was abandoned.

None of the three remaining methods is consistently superior to the others with regard to fuel economy. All three methods result in economy losses substantially greater than those employing mixture leaning.

Retarding the spark alone was eliminated from further consideration because the effectiveness is limited to only 50 to 60 percent. Any attempt to attain greater reductions by retarding the spark more than the amount of the vacuum advance, 20 degrees in this instance, seriously impairs car performance.

The only workable methods then are those employing mixture richening. Driveability is very good with rich mixtures, and it is possible to attain substantial reductions—75 percent or more—by this approach. But economy losses are also substantial, approximately 15 percent when 75 percent of the oxides of nitrogen are eliminated. There is no clear-cut choice between the mixture richening and mixture richening combined with spark retard. At 30 miles per hour, straight mixture richening is the more economical method, whereas at the higher speeds it seems advantageous to use both mixture richening and spark retard.

After studying the results of these tests, the mixture richening approach was selected for further study. A special carburetor, one that would supply rich mixtures at all speeds and throttle settings, was installed on a late model automobile. This special carburetor will be referred to as a "maximum performance carburetor." The effects of this carburetor on oxides of nitrogen and fuel economy were then evaluated in normal automotive service, as discussed in the following section.

EVALUATION OF THE "MAXIMUM PERFORMANCE CARBURETOR" IN AUTOMOTIVE SERVICE

The rich mixture control method was evaluated by comparing two cars with respect to their emission of oxides of nitrogen and fuel economy. The first car was equipped with the maximum performance carburetor. The second car, an identical model, had standard carburetion. Spark timing for both cars was checked and found to be essentially the same at all operating conditions. There was no noticeable difference in driveability between the two cars. Both were equally satisfactory. Other automotive problems which may be affected by rich carburetion, such as intake system deposits and valve and spark plug life, were not investigated.

Effect on oxides of nitrogen

To determine how effectively the rich mixture control method reduced oxides of nitrogen, an "average driving pattern" type of analysis was made. To explain this procedure briefly, average driving is defined in terms of the time spent at various operating conditions. The rate of emission of oxides of nitrogen (or other exhaust gas constituent of interest) is determined at each of the driving conditions. The composite or overall emission rate is calculated by combining the individual rates in proportion to the percent of time spent at each condition. A more accurate estimate undoubtedly could have been made if the emission rate had been measured continuously, but instrumentation to accomplish this was not available.

The complete analysis is presented in table I. Driving conditions were those determined by the traffic survey panel of the Automobile Manufacturers' Association to be typical of city-suburban driving in the Los Angeles area (4). Air-fuel ratios were determined from Orsat analyses. Concentrations of oxides of

nitrogen were determined by the PDS procedure. Engine airflow was measured with a viscous-flow-type air meter and recorded on oscillograph film. Emissions of oxides of nitrogen were calculated from concentration and airflow data, with the assumption that exhaust flow and airflow are equal on a dry molar basis. The percent of time that the average driver spends at each driving condition, according to the AMA survey, is shown in the third from last column. The amount of oxides of nitrogen (in standard cubic feet at 1 atmosphere and 70° F.) discharged from each car at each driving condition, when the car is driven 1 hour according to the AMA driving schedule, is shown in the last 2 columns. The sum of these values is the composite hourly emission.

Table 1 indicates that use of the maximum performance carburetor reduced the composite or overall emission of oxides of nitrogen over 90 percent. This is a very large reduction. The maximum performance carburetor markedly reduced the concentration of oxides of nitrogen during all cruise conditions and, more importantly, during all part-throttle accelerations. It is during these conditions when the greatest emissions of oxides of nitrogen normally occur. Concentration differences between the two cars seem directly related to air-fuel ratio differences, as predicted by the earlier work.

Effect on fuel economy

To determine overall fuel economy, the two cars were driven side-by-side over a specified route which simulated city-suburban type driving. Drivers were rotated regularly. Fuel consumption was recorded for 2,500 miles. The average fuel economy for each car during this period was:

	Miles per gallon
Car A, with maximum performance carburetor	11.8
Car B, with standard carburetor	15.9

The loss in economy attributed to the modified carburetor was 4.1 miles per gallon, or about 26 percent.

The type of driving at which the fuel economy measurements were made did not correspond exactly to the AMA driving schedule. For that reason, the calculated 90 percent reduction of oxides of nitrogen is not directly comparable to the measured 26 percent loss in economy. However, since both driving schedules are representative of city-suburban type driving, a comparison is believed justified.

General discussion

It is obvious then that the 90 percent reduction in the emisison of oxides of nitrogen was not obtained without cost. The 26 percent loss in economy is considerable, both in terms of dollars and in terms of natural resources. It seems likely, however, that the economy loss can be appreciably reduced if a smaller reduction in oxides of nitrogen is acceptable. An estimate is 15 percent economy loss at the 75 percent reduction level. The maximum performance carburetor described here was set to an air-fuel ratio of about 11 : 1. A constant air-fuel ratio of 12 or 12½ to 1 might be the best compromise between economy and effectiveness.

Essentially the only cost of this control method is the extra fuel that is consumed. To the motorist who drives his car 12,000 miles each year, the annual cost would be about $70 if oxides of nitrogen were to be reduced by 90 percent.

For a reduction of 75 percent, the annual cost is estimated at $40. These costs should be compared against those of other control methods when such information becomes available.

In these experiments, no special attempt was made to determine the emissions of carbon monoxide and hydrocarbons, but some pertinent data were obtained. Almost without exception, higher carbon monoxide concentrations were detected in the exhaust gases from the car equipped with the maximum performance carburetor.This is not unexpected in view of the well-established relationship between air-fuel ratio and carbon monoxide concentration. With hydrocarbons, the situation is not so clearcut. As indicated by table II, neither car produced higher hydrocarbon concentrations than the other under all operating conditions.

For years, a control method has been sought for reducing carbon monoxide and hydrocarbons in automobile exhaust gases. Such a method will be equally desirable when using the maximum-performance carburetor for controlling oxides of nitrogen. One of the most promising approaches to hydrocarbon control appears to be catalytic oxidation (5). The principle of catalytic oxidation combined with maximum-performance carburetion would provide a method of eliminating from automobile exhaust gases the most objectionable constituents, namely, carbon monoxide, hydrocarbons, and oxides of nitrogen.

SUMMARY

The amount of oxides of nitrogen in automobile exhaust gases can be greatly reduced by the use of a maximum-performance carburetor. Such a carburetor provides rich air-fuel mixtures at all driving conditions.

This marked reduction must be paid for by a sacrifice in fuel economy. Tests showed that a 90-percent reduction in oxides of nitrogen would cost the individual car owner about $70 a year. However, if a smaller reduction is acceptable, the cost will be somewhat less. For example, a 75-percent reduction is estimated to cost the car owner only $40 per year. These figures serve as a convenient yardstick against which to compare any other method of reduction.

The principle of catalytic oxidation combined with maximum performance carburetion would provide a method of eliminating from automobile exhaust gases the most objectionable constituents, namely, carbon monoxide, hydrocarbons, and oxides of nitrogen.

TABLE I.—*Calculated emission of oxides of nitrogen with standard and maximum performance carburetion*

Driving condition	Air-fuel ratio		NO_x concentration parts per million		Engine air flow SCFM	NO_x emission SCFH		Percent time at driving condition	NO_x emission per hour for driving condition SCFH	
	Standard	Maximum performance	Standard	Maximum performance		Standard	Maximum performance		Standard	Maximum performance
Idle	11.1	11.5	26	30	9	0.01	0.01	15.0	0.002	0.002
Cruise:										
20 miles per hour	13.4	12.0	430	120	16	.41	.11	6.9	.028	.008
30 miles per hour	13.5	10.9	1,050	106	27	1.70	.17	5.7	.097	.010
40 miles per hour	13.7	11.0	1,820	160	38	4.14	.37	2.7	.112	.010
50 miles per hour	13.8	11.1	2,780	220	50	8.34	.66	.7	.058	.005
Acceleration:										
0 to 60 miles per hour in 20 seconds	11.6	10.8	420	284	131	3.31	2.24	1.1	.036	.025
0 to 25 miles per hour in 11 seconds	13.4	11.0	1,910	167	69	7.92	.69	10.6	.840	.080
15 to 30 miles per hour in 12 seconds	13.9	11.2	2,230	169	59	7.88	.59	25.0	1.970	.148
Deceleration:										
50 to 20 miles per hour in 25 seconds			15	21	9	.01	.01	10.2	.001	.001
30 to 15 miles per hour in 11 seconds			17	38	9	.01	.02	11.8	.001	.001
30 to 0 miles per hour in 12 seconds			28	36	9	.02	.02	10.3	.002	.002
Composite NO_x emission in SCFH									3.146	.292

NOTE.—1. Acceleration and deceleration values are integrated averages.
2. Engine air flow rates for both cars were averaged. The car-to-car variation was no greater than the repeatability of the measurements.

TABLE II.—*Exhaust gas hydrocarbon concentration with standard and maximum performance carburetion*

Driving condition	Hydrocarbons—Mole (percent) [1]	
	Standard	Maximum performance
Idle	0.046	0.033
Cruise:		
20 miles per hour	.028	.041
30 miles per hour	.022	.042
40 miles per hour	.018	.040
50 miles per hour	.015	.036
Acceleration:		
0 to 60 miles per hour	.030	.029
0 to 25 miles per hour	.051	.039
15 to 30 miles per hour	.027	.035
Deceleration:		
50 to 20 miles per hour	>.30	.21
30 to 15 miles per hour	.20	.07
30 to 0 miles per hour	.14	.06

[1] As n-hexane. Analyses made with Liston Becker model 15 infrared analyzer.

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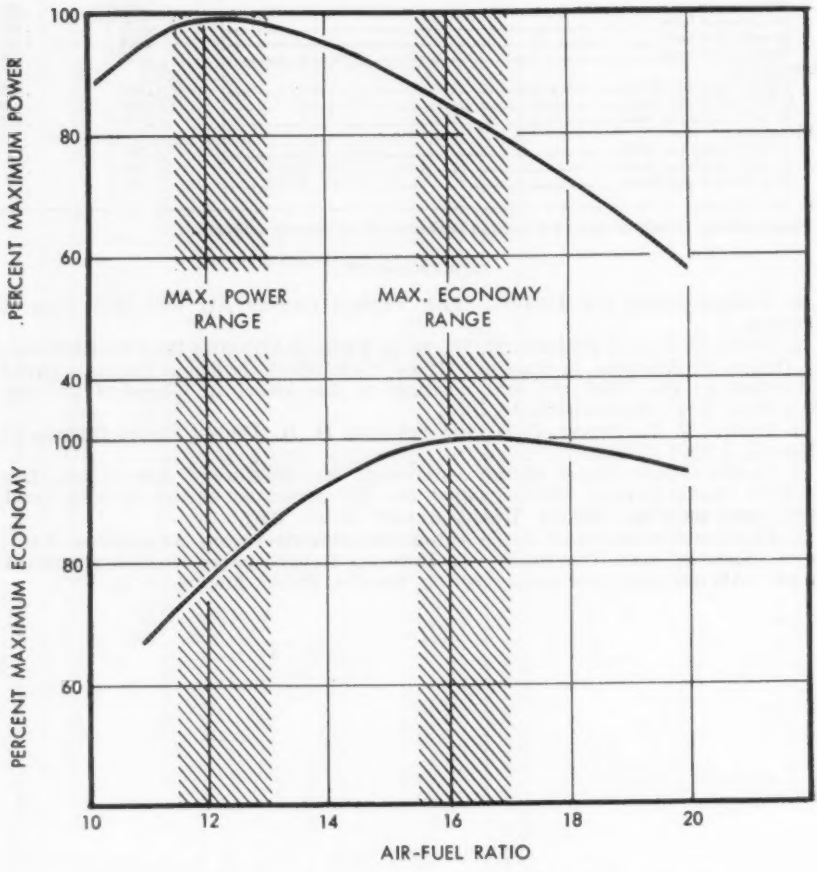

FIGURE 1.—Variation of power and economy with air-fuel ratio.

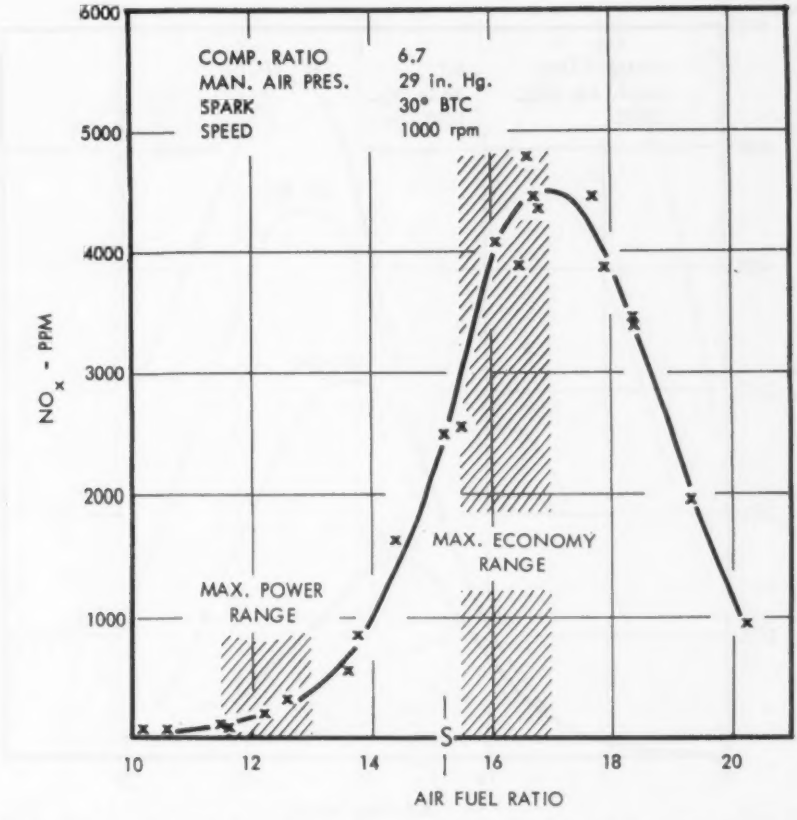

FIGURE 2.—Effect of air-fuel ratio on oxides of nitrogen. Single cylinder engine tests.

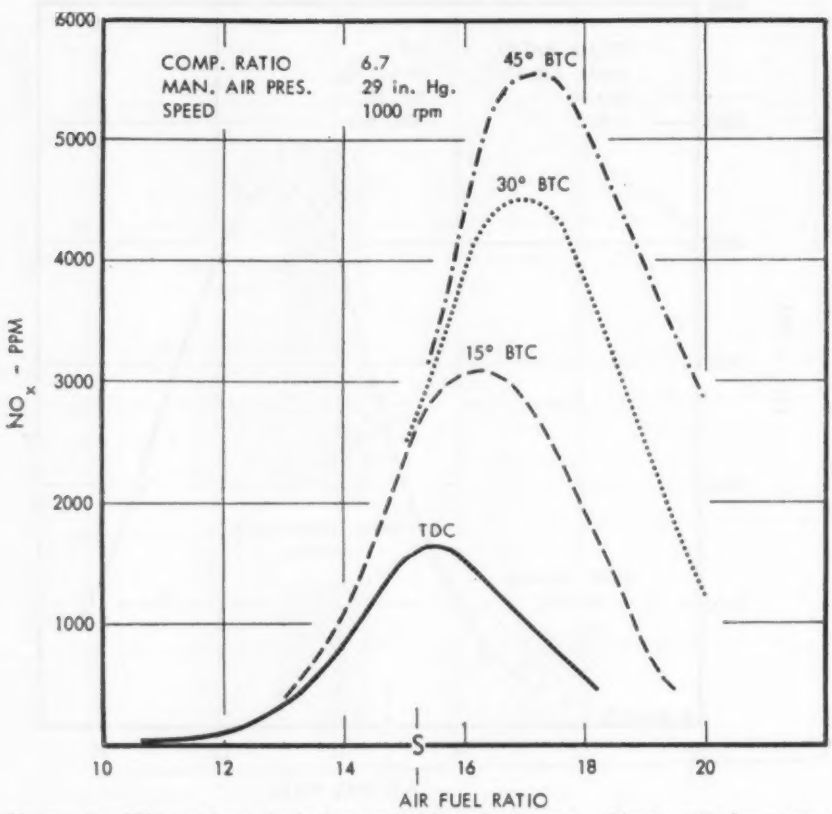

FIGURE 3.—Effect of spark timing on oxides of nitrogen. Single cylinder engine tests.

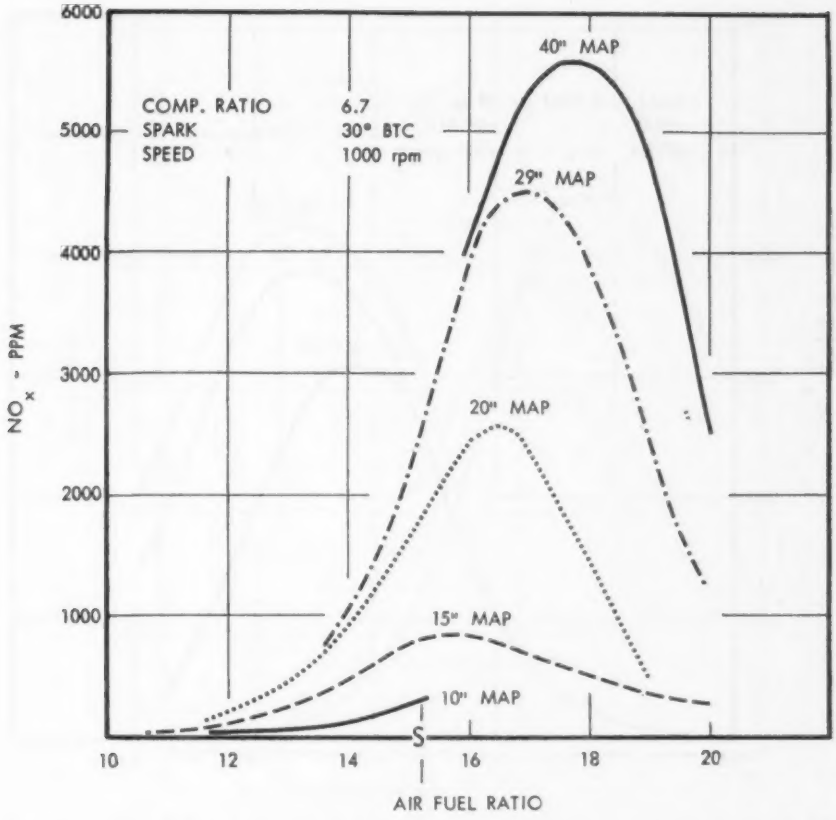

FIGURE 4.—Effect of manifold air pressure on oxides of nitrogen. Single cylinder engine tests.

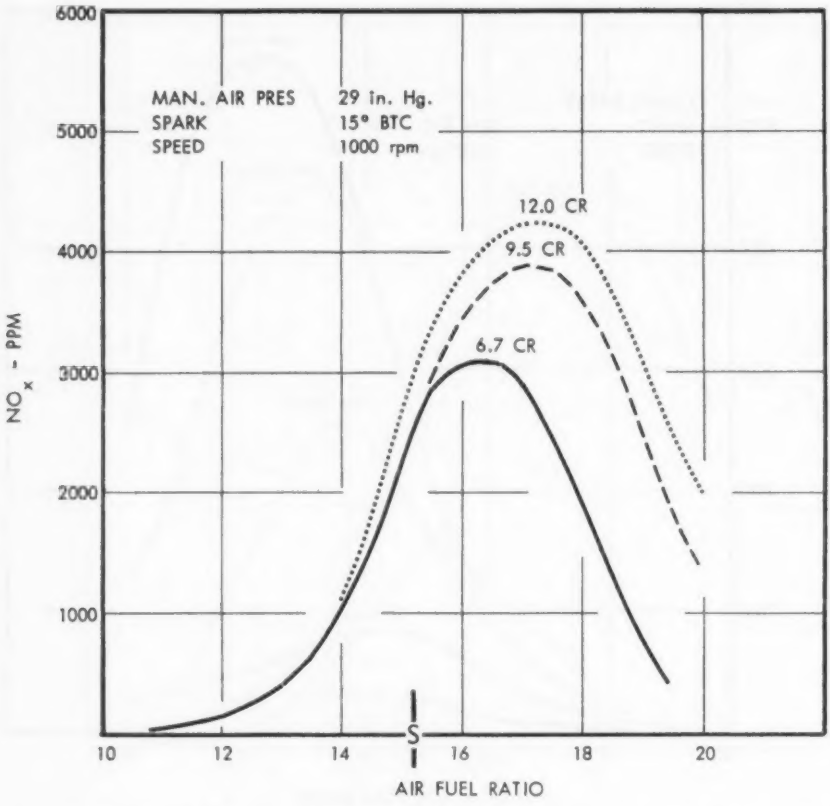

FIGURE 5.—Effect of compression ratio on oxides of nitrogen. Single cylinder engine tests.

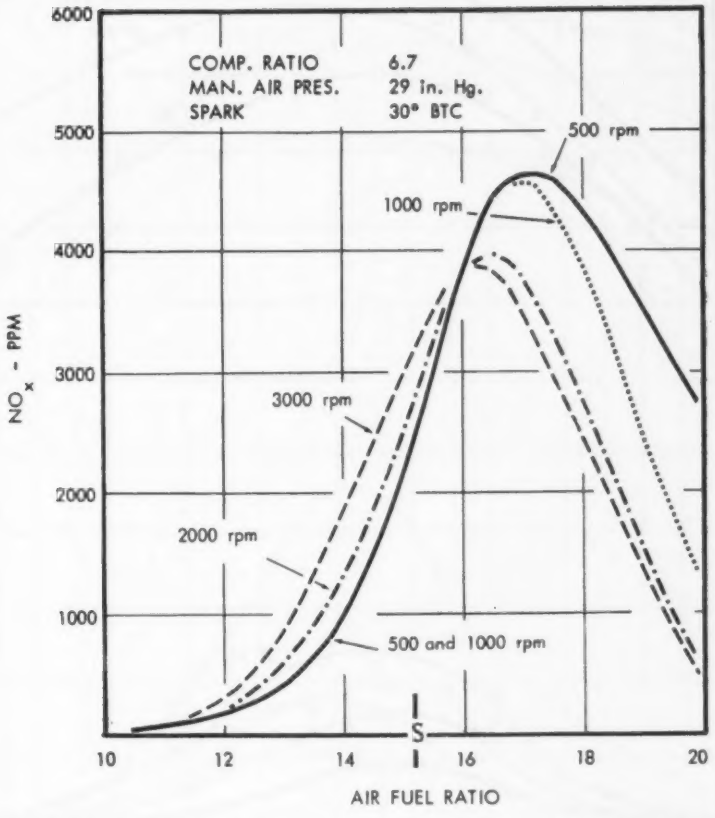

FIGURE 6.—Effect of engine speed on oxides of nitrogen. Single cylinder engine tests.

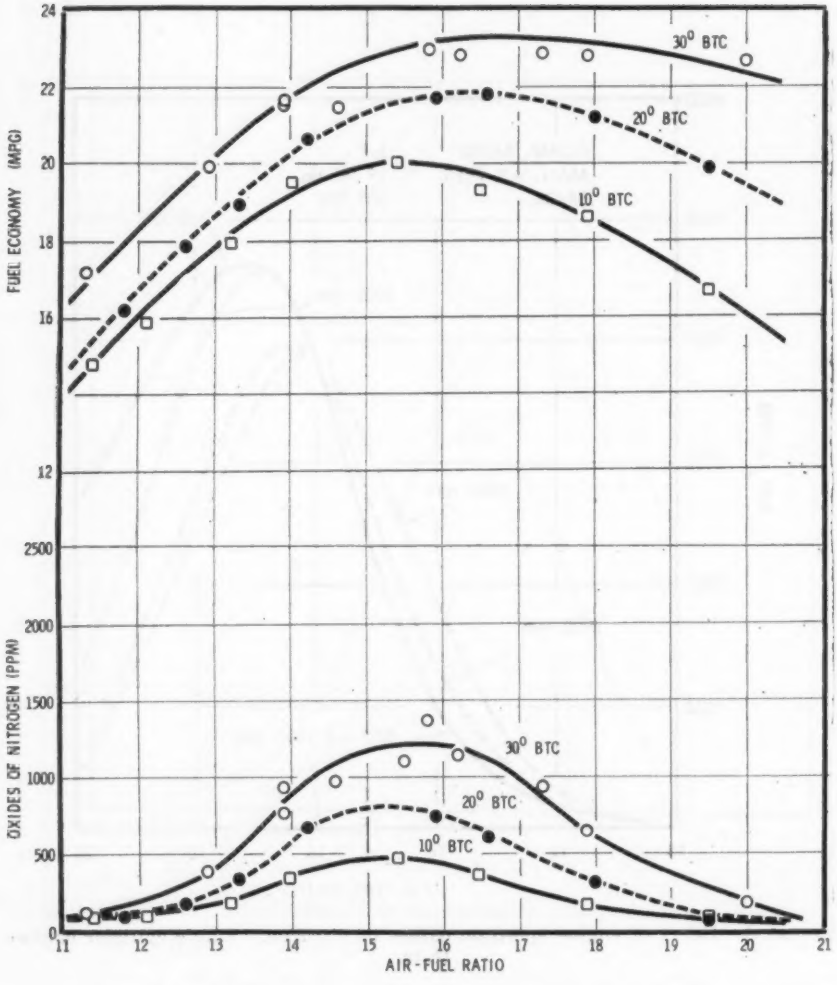

FIGURE 7.—Effect of air-fuel ratio and spark timing on fuel economy and oxides of nitrogen. Automobile tests at 30 miles per hour.

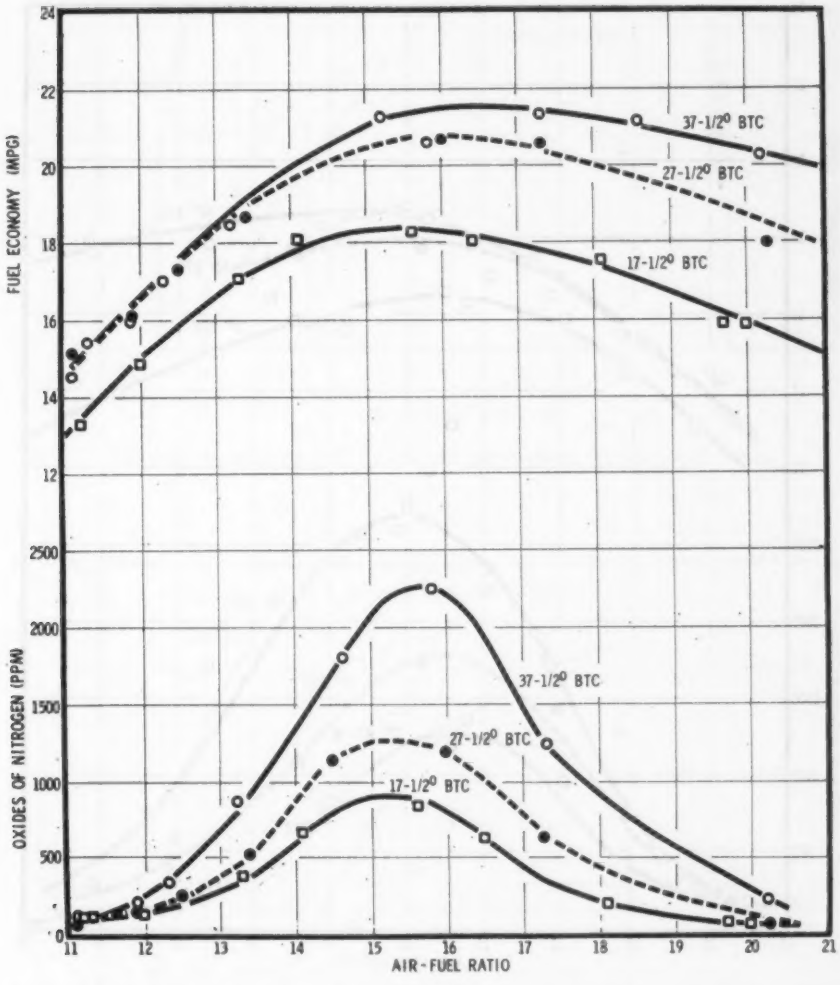

FIGURE 8.—Effect of air-fuel ratio and spark timing on fuel economy and oxides of nitrogen. Automobile tests at 45 miles per hour.

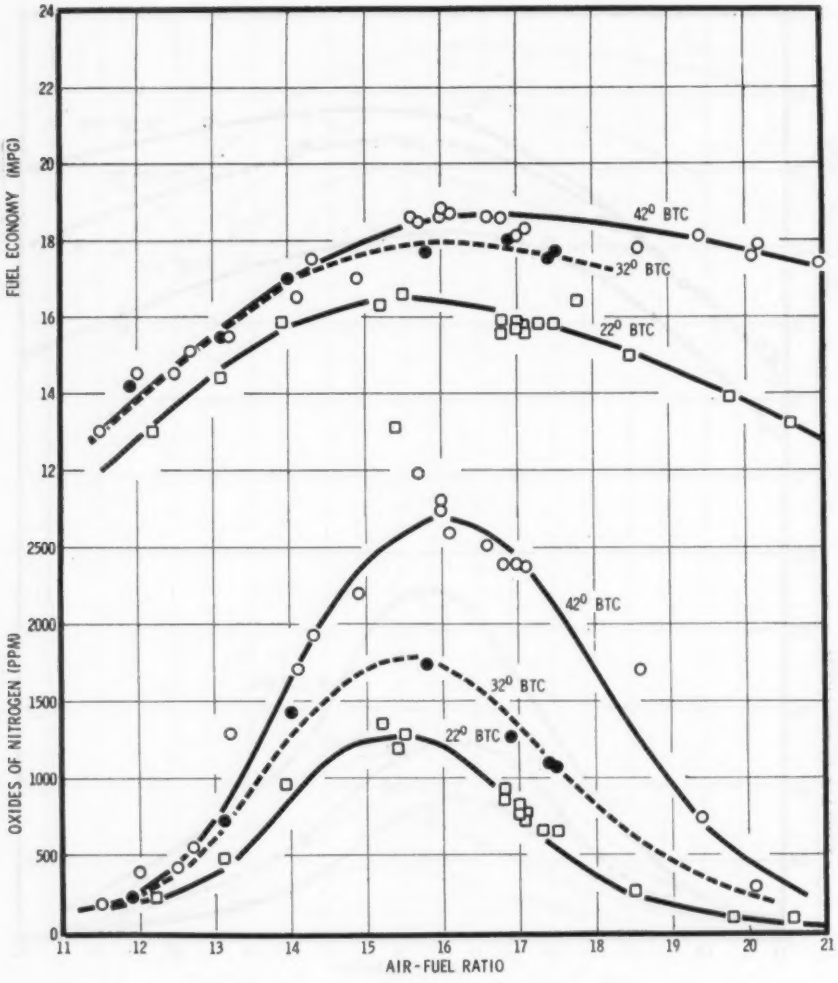

FIGURE 9.—Effect of air-fuel ratio and spark timing on fuel economy and oxides of nitrogen. Automobile tests at 60 miles per hour.

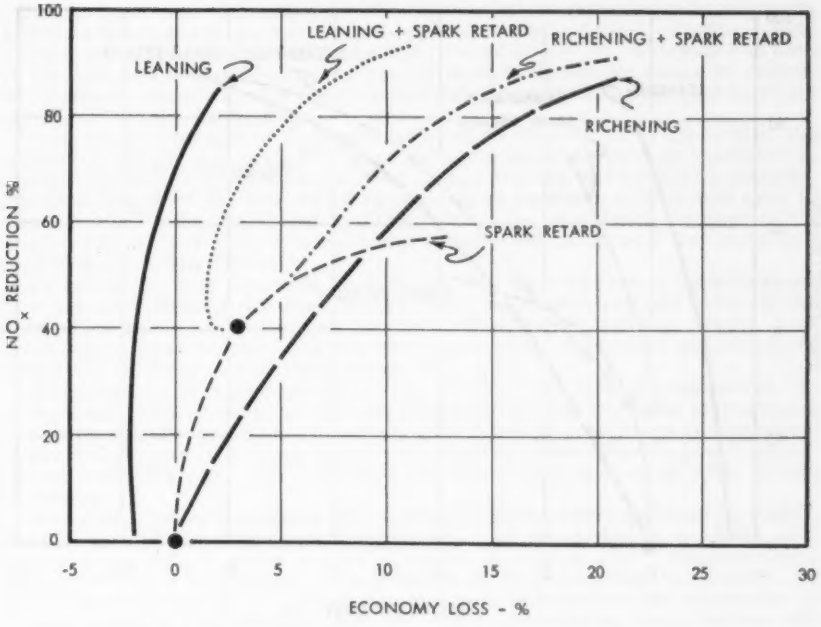

FIGURE 10.—Comparison of control methods at 30 miles per hour.

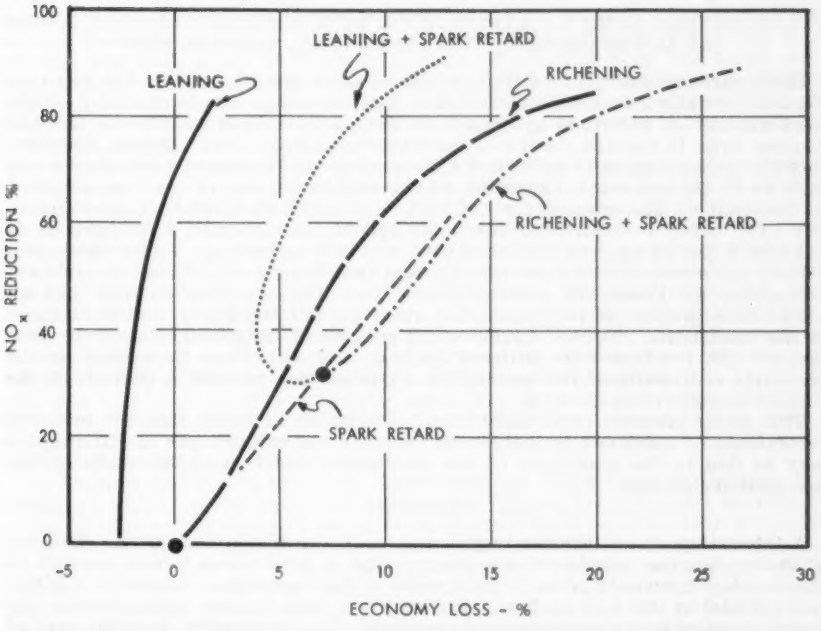

FIGURE 11.—Comparison of control methods at 45 miles per hour.

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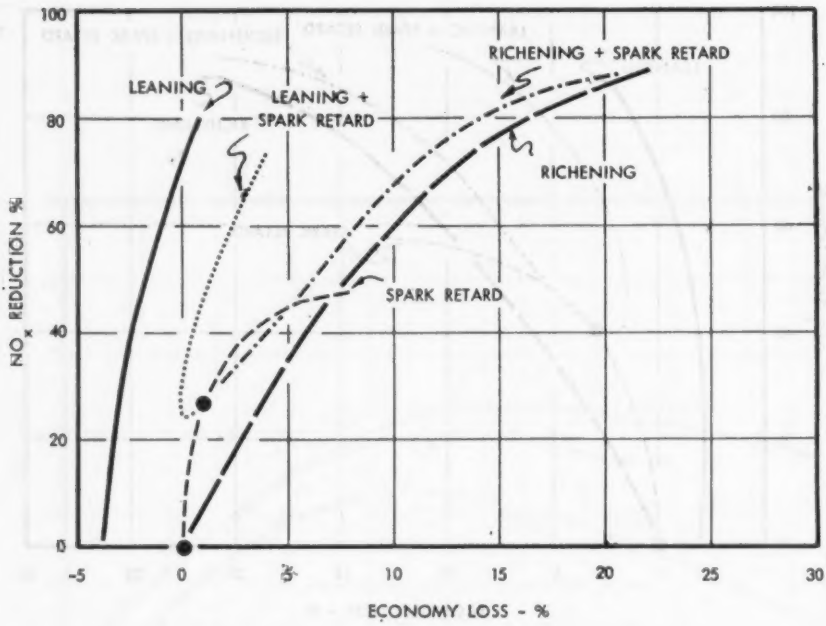

FIGURE 12.—Comparison of control methods at 60 miles per hour.

FLAME QUENCHING AT THE WALLS OF AN INTERNAL COMBUSTION ENGINE

By W. A. Daniel, research staff, General Motors Corp., Detroit, Mich.

(To be presented at the Sixth International Symposium on Combustion, session XI–B, Yale University, New Haven, Conn., August 24, 1956)

Hydrocarbons which are found in the exhaust gas of automobiles are considered partially responsible for the Los Angeles smog. About one-third of the total amount of unburned hydrocarbons exhausted by automobiles in the Los Angeles area is emitted during deceleration operation. (1) During deceleration the concentration of unburned hydrocarbons in the exhaust gas may be as high as 60 percent when expressed as the weight percent of the fuel supplied to the engine. The reasons for the high concentrations have been established. (2) The other two-thirds of the total amount of unburned hydrocarbons is exhausted during full-throttle, road-load, and idle operation. Under these conditions the concentrations are usually less than 5 percent. Three possible explanations for these low concentrations are: (1) the hydrocarbons are an equilibrium product of the combustion reaction, (2) the highly turbulent gases in the combustion chamber enable small pockets of unburned mixture to pass through the reaction zone without igniting, and (3) flame quenching at the relatively cool walls of the combustion chamber may prevent a portion of the fuel-air mixture from reacting.

This paper presents experimental evidence which indicates that the low concentrations of unburned hydrocarbons found in the exhaust gas of automobiles may be due to the quenching of the combustion reaction at the walls of the combustion chamber.

EQUIPMENT

A laboratory single-cylinder engine was used for the investigation. The top of the combustion chamber was a quartz window with which it was possible to observe the region next to the vertical walls of the combustion chamber in a direction parallel to the wall surface. Figure 1 is a view looking down through the quartz window into the combustion chamber. The combustion chamber was of the L-head type, and the engine was operated at a compression ratio of 6.7.

Engine speed was maintained at 500±10 revolutions per minute by means of a dynamometer, and a spark timing of top dead center was used. Engine cooling water temperature and the oil temperature were 150°±5° F. Propane was used as the fuel, and both fuel flow and airflow were measured by means of critical flow nozzles. Engine inlet pressure was adjusted by regulating the rate at which air was admitted to the engine.

To obtain photographs of the flame radiation in the vicinity of the wall of the combustion chamber, a portrait-type camera was equipped with an extension to increase the lens to film distance so that a magnification of 10 could be obtained. The focal length of the lens was 3 inches and an aperture of f/40 was used to obtain a depth of field comparable to the depth of the combustion chamber (0.375 inch). The field of view of the camera is indicated in figure 1 and measured approximately 0.4 by 0.5 inch.

A stroboscopic disk was used between the lens and the film to limit to about 10 crank angle degrees the time during which an observation was made of the flame front passing a given wall location. Film exposure times ranged from about 1 hour to 23 hours; therefore, each photograph represented an average of from about 15,000 to about 300,000 cycles.

An Eastman high-speed motion-picture camera was used to photograph the entire combustion chamber so that the time required for the flame to propagate across the chamber could be determined. One frame of a sequence is reproduced as figure 2 to show an average flame-front position at the time the quench photographs were obtained. The film speed for this picture was about 1,500 frames per second.

The exhaust gas of the engine operated at full throttle was analyzed for hydrocarbons by infrared absorption spectroscopy. An absorption path length of 2 meters was obtained using a multiple pass absorption cell. The gases were analyzed at room temperature at a pressure of 750 millimeters of mercury. A Perkin-Elmer model 99 monochromator was used to determine the absorption at a wavelength of 3.35 microns, and the total hydrocarbon concentration was assumed proportional to the absorption at 3.35 microns.

PHOTOGRAPHS OF THE QUENCH ZONE IN AN ENGINE

For most engine conditions visible radiation is emitted from both the flame front and the hot gases behind the flame front (see, for example, fig. 2). The latter radiation is usually referred to as the afterglow and may have no relation to any chemical reaction. As a result of turbulence the afterglow might conceivably approach closer to the wall surface, or through heat loss might end further from the wall surface than the flame front; therefore, to determine photographically if a quench zone exists at the wall of the combustion chamber at the time the flame front passes the wall surface, it was necessary to preferentially record the radiation from the flame front.

It was experimentally difficult, however, to obtain a separation of the radiation of the flame front from that of the afterglow due to cyclic variation. Variation occurred in both the time at which radiation could pass through the opening in the stroboscopic disk due to gear backlash, and in the position of the flame front with respect to the field of view for a given timing of the stroboscopic disk. In addition, the relative flame front speed was great enough so that during the time radiation could pass through the opening in the stroboscopic disk and be recorded on the film, the flame front could move across the field of view. (Shorter stroboscopic disk opening times were prohibited by the exposure time required to obtain a film image which in turn was limited by how long the window remained clear.) As a result of these complications only a partial separation of the flame-front radiation from that of the afterglow was obtained. The partial separation was achieved by adjusting the stroboscopic disk timing so that a flash of radiation from the combustion chamber was visible through the lens in about one-half of the cycles.

In figure 3 are shown four quench photographs which serve to indicate the effects of both fuel-air ratio and engine inlet pressure. The wall surface is perpendicular to the plane of the photograph and the top of the wall is located in the lower half of each photograph. The radiation from the combustion chamber is recorded in the top half of each photograph. A dark zone or quench zone may be seen between the wall and the chamber. The width of the quench zone may be estimated from the indicated distances between the reference lines which were scribed on the top surface of the wall. The top of the wall was

illuminated by a projected spot of light which spilled over into the combustion chamber.

The apparent quench zone extends along the entire length of the wall surface in the pictures, and no definite flame-front position is apparent. If the radiation from the combustion chamber were divided into thirds by two lines drawn perpendicular to the wall, then the image in the right-hand third is probably due essentialy to radiation from the flame front but also due to some afterglow radiation. The image in the middle third is probably due to partly flame-front radiation and partly to afterglow, and the image in the left-hand third is probably due to mostly afterglow radiation. Within the accuracy of the measurements no difference in quench zone thickness across a given picture was detected.

In figure 4 are shown densitometer traces of the negatives of each of the quench photographs of figure 3 and are located in the corresponding positions. The different exposure times noted were required since the flame intensity decreased as the fuel-air ratio was changed from stoichiometric and also as the engine inlet pressure was decreased. With a change in exposure time the illumination of the wall was changed in an attempt to obtain about the same image density for both flame and wall for a given picture. In figures 3B and 4B the camera magnification was 5, but in the printing process an enlargement was made so that an effective magnification of 10 was obtained and these figures are thus directly comparable with the others.

Each quench photograph negative was traversed by the densitometer at right angles to the wall surface and in about the middle of each negative. The percent absorption of the densitometer beam by the negative is indicated along the ordinate and the distance in inches in a plane parallel to the combustion chamber floor is indicated along the abscissa. The apparent quench zone thickness (q_d) is indicated on each trace. It may be seen that at full throttle the quench distance increased from about two one-thousands of an inch (fig. 4A) at a propone-air weight ratio near stoichiometric (0.062) to about four one-thousandths of an inch at a fuel-air ratio of 0.10 (fig. 4D) and to about three one-thousandths of an inch at a fuel-air ratio of 0.045 (fig. 4C). With approximately stoichiometric mixtures, the quench distance increased from about two one-thousandths of an inch (fig. 4A) to about fifteen one-thousandths of an inch (fig. 4B) when the engine intake manifold pressure was decreased from about 29.4 inches of mercury to about 9.4 inches of mercury absolute.

Another factor to be considered in interpreting the quench photographs arises from a consideration of figure 5. To observe the quench zone the optical axis of the camera was alined with the wall surface. Upon examination of the relative position of the camera lens and the cross sectional view of the combustion chamber, it becomes apparent that if point sources of uniform intensity of radiation were assumed along the floor of the combustion chamber all the way over to the wall surface (no quench zone), the lens would discriminate against those point sources located closer to the wall than the point m since a portion of the lens area would be lost to those point sources due to the top edge of the wall at t. Thus an apparent decrease in radiation in the vicinity of the wall would be recorded on the film. This discrimination by the lens or wall-shadow effect would reach a maximum for the point source located at the intersection of the wall surface and the floor of the combustion chamber and the intensity decrease would amount to a factor of one-half, since one-half the lens area would be in the shadow of the top edge of the wall for this point. The distance from the wall to m is easily calculated knowing the distance from the lens to the top edge of the wall, the lens diameter, and the depth of the combustion chamber. For the camera settings used for figure 4A the distance from the wall to m is 0.0025 inch; for figure 4B, 0.0250 inch; and for figures 4C and 4D, 0.0045 inch. A comparison of these values with the corresponding apparent quench distances indicates that the wall-shadow effect must be considered.

A photograph of a standard gray scale taken with similar film and developed in a similar manner was used to convert the density of the negative of figure 4D to the relative intensity of the source. It was found that the minimum intensity of radiation recorded in the apparent quench zone was less than one-third the intensity of radiation found further from the wall than m. Since the wall-shadow effect could only decrease the intensity of radiation to one-half, it may be concluded that the decrease in radiation in the vicinity of the wall is due to some factor in addition to the wall-shadow effect.

Although the possibility exists that still other unknown optical effects may cause the decrease in radiation in the vicinity of the wall, the variation of the

width of the decrease in radiation zone with engine conditions supports the assumption that the decrease in radiation is primarily due to wall-quenching phenomena.

A COMPARISON OF THE EXPERIMENTAL QUENCH DISTANCES WITH CALCULATED QUENCH DISTANCES

Friedman and Johnston (3) determined quench distances for propane-air flames by a rectangualr-slot-burner flashback method at pressures between 0.0832 and 2.77 atmospheres, at temperatures between 75° F. and 715° F., and at fuel-air ratios between 0.10 and 0.042. From their data they determined two relations for predicting the quench distance (q_d) :

(1) $q_d \propto \frac{1}{P^{0.91}T^{0.50}}$ for stoichiometric and rich mixtures.

(2) and $q_d \propto \frac{1}{P^{0.76}T^{0.85}}$ for lean mixtures.

where P is the absolute pressure and T is the absolute temperature of the gas in the quench zone.

A quench distance in the engine may be calculated using (1) and (2) by determining the pressure and temperature existing in the engine. Pressure records were obtained at the engine conditions used for obtaining the data shown in figures 3 and 4 and are shown in figure 6. Three points are indicated on each pressure record: the time of occurrence of the ignition (X), the time during which the quench photographs of figure 3 were obtained (Y), and the time at which combustion was complete (Z). The temperatures of the gases in the quench zone are estimated to differ only slightly from the engine coolant temperature (see table 1). By choosing a value for the quench distance determined by Friedman and Johnston at a known pressure and temperature, a quench distance may be calculated for other pressures and temperatures. Using the Friedman and Johnston value of 0.0355 inch for q_d at P=1 atmosphere and T=535° R and determining P′ (the average pressure) from figure 6 for the time during which the quench photographs were obtained, the quench distances given in table 1 were obtained.

TABLE 1

F/A	Engine pressure P′ (atmosphere)	Engine temperature T′ (degrees Fahrenheit)	Calculated quench distance	Experimental quench distance (fig. 4)
0.100	13.4	650	0.0030	0.004
0.062	15.0	675	.0027	.002
0.045	13.4	650	.0042	.003
0.065	4.0	625	.0093	.015

The calculated and experimentally determined values of the quench distance as shown in table 1 agree remarkably well considering the assumptions involved in the calculations and all the possible differences between the engine and a burner. This agreement provides additional evidence for the existence of wall quenching in an internal combustion engine.

UNBURNED HYDROCARBONS IN THE EXHAUST GAS OF THE ENGINE

In figure 7 are shown results obtained by analyzing the exhaust gas of the single-cylinder engine operated at full throttle for unburned hydrocarbons. The ordinate is the relative hydrocarbon concentration with the concentration at stoichiometric arbitrarily chosen as one and the abscissa is the fuel-air weight ratio. A minimum hydrocarbon concentration occurred at a somewhat leaner mixture than stoichiometric.

To evaluate the possibility that these unburned hydrocarbons are due to a wall quenching of the flame reaction, the following assumptions were made: (1) The dark region between the wall and the flame radiation (fig. 4) actually defines the limits of a quench zone, (2) a homogeneous mixture of fuel and air exists in the

combustion chamber prior to inflammation, (3) none of the hydrocarbons existing in the quench zone are completely oxidized, either during or after the flame front passage, and (4) the quench zone is of uniform thickness over all the combustion chamber surface exposed to the flame front. The fourth assumption ignores the effects of changing pressures and temperatures during the cycle as well as the hotter surface of the quartz window which was used as the top of the combustion chamber.

Using these four assumptions and the measured quench distances indicated in figure 4 and the surface area and volume of the combustion chamber at the time the combustion was completed, a quench volume (V_q) was calculated. The ratio of the quench volume to the total volume (V_t) at the time of the completion of combustion is given in table 2.

TABLE 2

F/A	V_q/V_t	Relative V_q/V_t	Relative hydrocarbon concentration (fig. 7)
0.100	0.147	1.65	2.4
0.062	.0089	1.00	1.0
0.045	.0110	1.24	1.1

In table 2 a comparison may be made between the relative values of V_q/V_t and the relative unburned hydrocarbon concentrations obtained from figure 7. The corresponding relative values of V_q/V_t and of hydrocarbon concentration are in fair agreement and would indicate that a large part of the unburned hydrocarbons found in the exhaust gas could occur because of a wall quenching of the combustion reaction.

Converting the ratio V_q/V_t to percent unburned hydrocarbons at the end of combustion and calculating a similar value for the light load engine condition (9.4 inches of mercury inlet pressure) values of 0.89 and 3.1 percent unburned hydrocarbons respectively are obtained for a stoichiometric fuel-air ratio. These values are comparable to the values obtained by other workers (4, 5) from an analysis of automobile exhaust gases for comparable engine inlet pressures.

SUMMARY

Experimental evidence is given which indictes that wall quenching of the combustion reaction occurs in an internal combustion engine. The apparent quench distances observed are in agreement with the quench distances calculated from burner data at approximately the same pressures and temperatures. In addition, the observed quench distances are of the right order of magnitude to account for the unburned hydrocarbons found in the exhaust gas of automobiles operated in the range of full throttle and road load.

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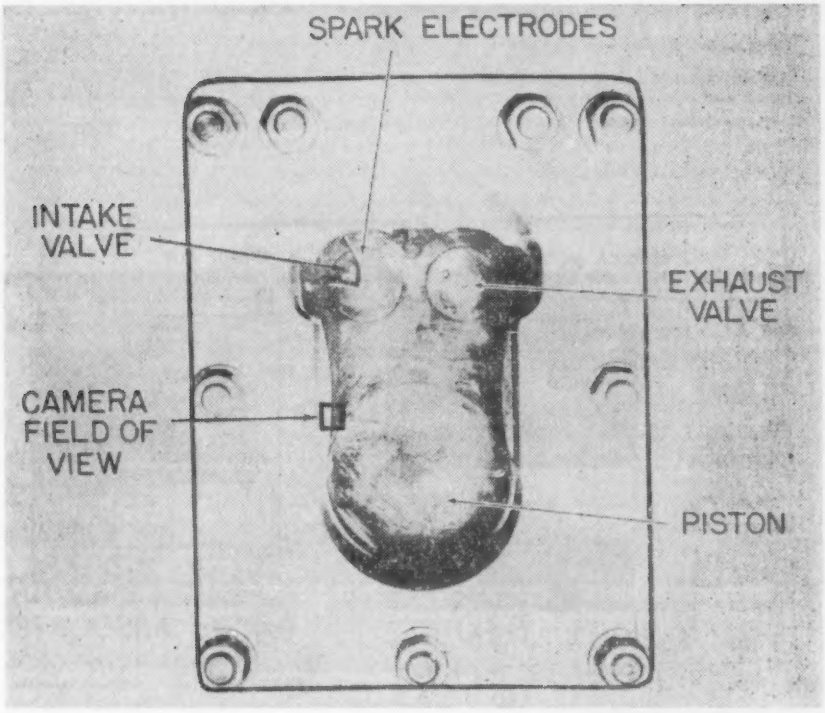


FIGURE 1.

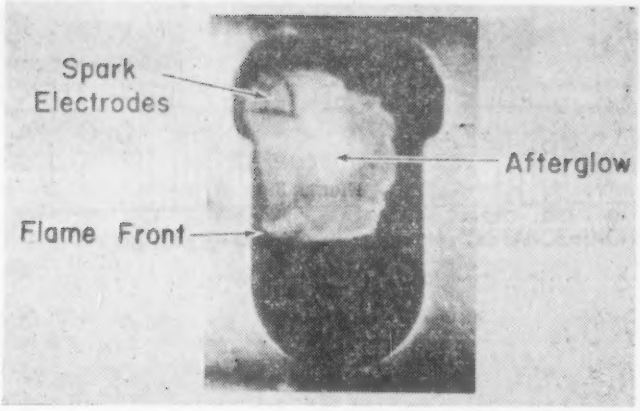
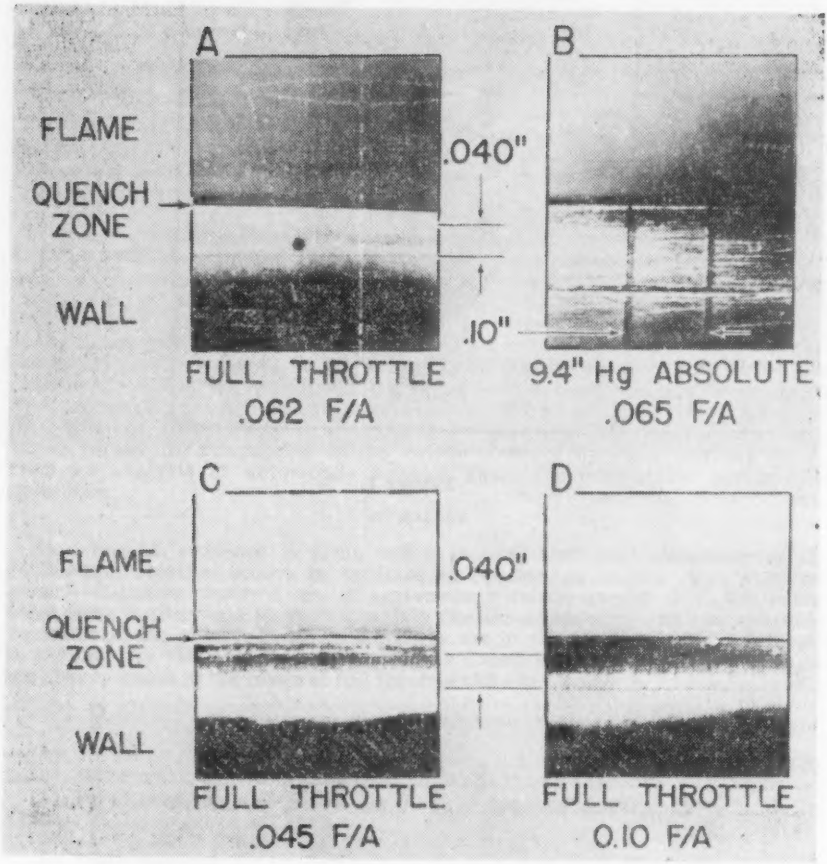


FIGURE 2.


A
B
FLAME
QUENCH ZONE
WALL
.040"
.10"
FULL THROTTLE
.062 F/A
9.4" Hg ABSOLUTE
.065 F/A
C
D
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.040"
FULL THROTTLE
.045 F/A
FULL THROTTLE
0.10 F/A

FIGURE 3.

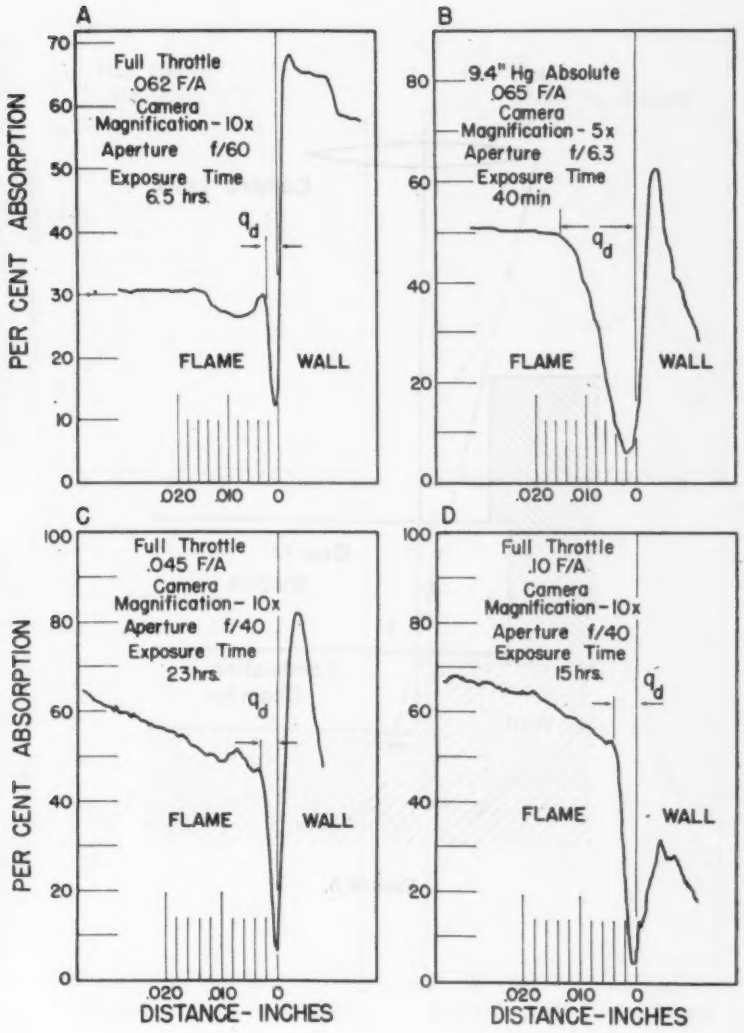
A
Full Throttle
.062 F/A
Camera
Magnification - 10x
Aperture f/60
Exposure Time
6.5 hrs.
q_d
FLAME
WALL
B
9.4" Hg Absolute
.065 F/A
Camera
Magnification - 5x
Aperture f/6.3
Exposure Time
40 min
q_d
FLAME
WALL
C
Full Throttle
.045 F/A
Camera
Magnification - 10x
Aperture f/40
Exposure Time
23 hrs.
q_d
FLAME
WALL
D
Full Throttle
.10 F/A
Camera
Magnification - 10x
Aperture f/40
Exposure Time
15 hrs.
q_d
FLAME
WALL
PER CENT ABSORPTION
PER CENT ABSORPTION
.020 .010 0
DISTANCE - INCHES
DISTANCE - INCHES

FIGURE 4.

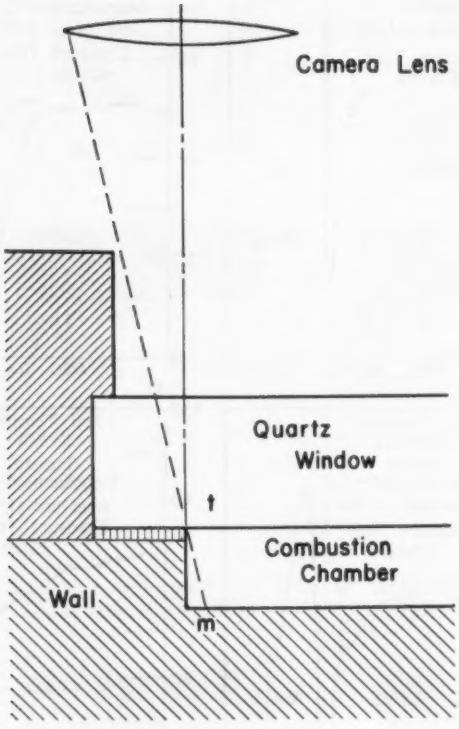

FIGURE 5.

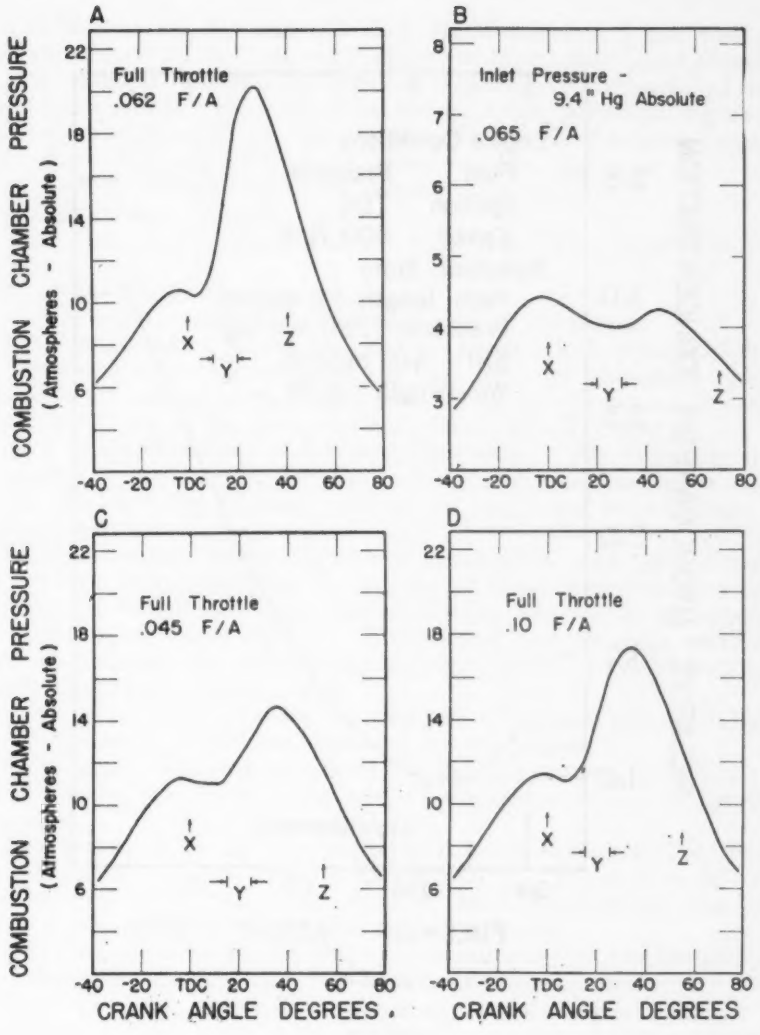
A
B
C
D
Full Throttle
.062 F/A
Inlet Pressure -
9.4" Hg Absolute
.065 F/A
Full Throttle
.045 F/A
Full Throttle
.10 F/A
X
Y
Z
COMBUSTION CHAMBER PRESSURE
(Atmospheres - Absolute)
-40 -20 TDC 20 40 60 80
CRANK ANGLE DEGREES

FIGURE 6.

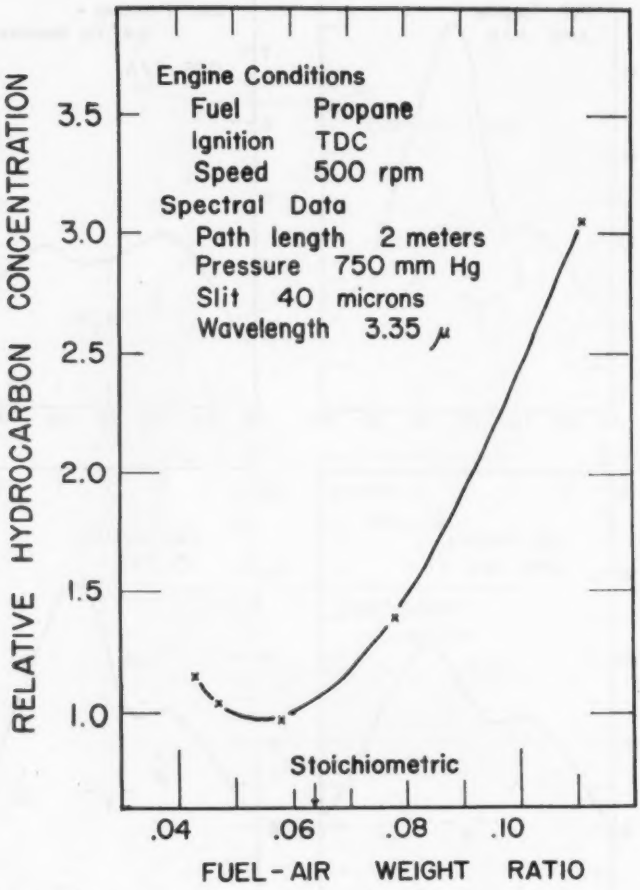
Engine Conditions
Fuel Propane
Ignition TDC
Speed 500 rpm
Spectral Data
Path length 2 meters
Pressure 750 mm Hg
Slit 40 microns
Wavelength 3.35 μ
RELATIVE HYDROCARBON CONCENTRATION
3.5
3.0
2.5
2.0
1.5
1.0
Stoichiometric
.04
.06
.08
.10
FUEL - AIR WEIGHT RATIO

FIGURE 7.

Mr. LOSER. Thank you very much, Doctor.
Dr. FISHER. Thank you.
Mr. LOSER. The next witness is Mr. Jack Merelman.
Would you please identify yourself, sir.

STATEMENT OF JACK M. MERELMAN, ASSOCIATE GENERAL COUNSEL, NATIONAL INSTITUTE OF MUNICIPAL LAW OFFICERS

Mr. MERELMAN. My name is Jack M. Merelman. I am associate general counsel of the National Institute of Municipal Law Officers.

The National Institute is a national organization composed of more than 1,000 member municipalities and counties, participating as the office of chief legal officer, whether identified as chief solicitor, county counsel, et cetera. I have a brief statement, Mr. Chairman.

Mr. LOSER. Without objection, you may proceed.

Mr. MERELMAN. Thank you.

Mr. LOSER. I understood that you wanted to leave, if possible, by 4 o'clock.

Mr. MERELMAN. That is right, sir.

Mr. LOSER. You may make your statement as you please.

Mr. MERELMAN. I heard Mr. Kennedy's excellent presentation to the subcommittee this morning. I find that our statement closely parallels his, in that ours in effect more or less constitutes a reiteration or reaffirmation of the points he made there this morning.

That is Mr. Kennedy of Los Angeles County. Mr. Kennedy incidentally is a nationally known municipal expert, and has been a leader in the affairs of the National Institute of Municipal Law Officers for many years.

While we speak essentially for municipalities and their citizens, we at once recognize that the subject of these proceedings vitally touches the health and happiness of every American, be he urbanite, suburbanite, or rural dweller. I commend you on your searching interest in the matter at hand and on your careful and deliberate consideration of the issues involved.

I firmly believe that these sessions will contribute substantially to the furtherance of the life abundant for all people.

Pollution, in its many unpleasant forms, is a national problem. In many places, the creeping sickness of air and stream is a national disgrace.

This morning we are concerned with air pollution and its detrimental effect on those who are exposed to it. The subject bill fills another gap in the mounting attack at the Federal, State, and local levels on the whole broad problem of air pollution.

Air contamination has reached such magnitude that the Department of Health, Education, and Welfare, on the recommendation of the Surgeon General, has called a national air pollution conference for November of this year. One important purpose of this conference will be to deal with air pollution problems which cannot be solved at the State or local levels. President Eisenhower, it will be recalled, in his special health message of January 31, 1955, urged further studies and positive steps toward the realization of clean, fresh air for all of our people.

The Air Pollution Act of 1955 (Public Law 159) authorized a 5-year program of Federal assistance to States, counties, municipalities, and other public agencies in the war on dangerous and distressing fumes and smoke.

The Ad Hoc Interdepartmental Committee on Community Air Pollution, appointed by the Secretary of Health, Education, and Welfare at the request of the President, urged a broad Federal program of research and technical assistance in ridding the air of all manner of noxious contaminants.

The Interdepartmental Committee also reaffirmed the principle of State and local responsibility for community air pollution control. Municipalities recognize both the problem and their duties for its correction.

But effective supplementary action by the Federal Government within its sphere of powers is imperative.

Scientific studies reveal that certain aspects of control are not susceptible of successful handling on a strictly State, municipal or local basis. The Federal Goverment by regulating the source so as to eliminate the very possibility of noxious deleterious fumes from a known generator will ease the State and local burden appreciably.

The National Institute of Municipal Law Officers has endeavored to offer guidance to municipalities in the adoption of sound, workable and judicially acceptable remedial programs.

Most Americans now live in urban places, and it is this larger urban segment of our population who suffer most from pollution of the air. Contaminated air produces stinging eyes, tears, burning nose and throat and coughing.

Every day this noisome irritation produces extreme discomfort for millions upon millions of our people. Efficiency of workers in crowded cities is impaired and there are possible unhealthful effects. Moreover, there is the psychological consideration that life is just not as pleasant when people sluggishly go about their business in the bleak atmosphere of grimy, choking, dirtladen air.

But the problem of aerial sewage does not stop with the thickly populated industrial areas.

Its national character is revealed by studies showing alarming crop damage, in outlying agricultural areas, caused by harmful air particles which drifted over from an urban area.

The desperate situation in which we find ourselves is not overdramatized when we say that the very air we breathe is being used as a common sewer where fumes, gases and all manner of polultants from the widest variety of generators are dumped.

Observed in this light it is shockingly apparent that we are fast dissipating a limited natural resource. In many places the air in which we live has just about reached the saturation point—"crossed the smog threshold"—and cannot be expected to absorb further contamination and still be healthful.

The NIMLO report distinguished "dense smoke" from contaminants in the nature of fumes, gases, soot, cinders and noxious acids.

I believe the Representative from Maryland raised the question as to whether, after all, the problem is not twofold, dense smoke as distinguished from contaminants in the nature of fumes and other particles in the air.

A more comprehensive identification of air contaminants has been suggested as follows:

Unsaturated hydrocarbons: Storage of petroleum products, petroleum refinery processes, motor exhausts, petroleum hauling and marketing.

Dust and fumes: Mineral and earth processes, metals industries, grain and feed processes; chemical, paint, and soap industries.

Smoke: Domestic incinerators, open fires, motor exhausts; commercial, industrial, and municipal incinerators; fuel oil burners.

Sulfur dioxide: Fuel oil burners, petroleum refinery processes, chemical processes.

Much progress has been made in regulating smoke even though it still remains as one of the most injurious nuisances to persons and property.

The Ringelmann chart, and other standards by which the density of smoke is measured, have proved effective and the courts have found them acceptable.

But with an ever-increasing number of automobiles and with congestion threatening to paralyze cities it is imperative that we lay stress, legally, technically, and administratively, on the other sources of undesirable air particles, including the problem of controlling unburned hydrocarbons from motor exhausts.

The subcommittee may ask what has been done since 1947. At the Institute, we still receive requests asking what can we do, for example, about the incinerator, which is still the problem?

What can we do about burning tires and wrecked vehicles in junkyards?

I would say since 1953 there seems to be an increase in the number of queries raising the question of "Can we require that the heavier motor vehicles, such as trucks and buses, place the exhaust pipe at the top of the vehicle, or, if not that, can we require that the exhaust pipe be placed at such an angle that the fumes will be blown toward the sky rather than the pedestrian?"

Because there is no visible emission from the tailpipes of most motor vehicles, it is difficult for people to realize that they are a serious contributor to the unhealthy haze which enshrouds cities. Studies are going forward now to find a device or method which would absorb the exhaust discharge, or achieve complete combustion in the exhaust system.

Sweeping legislative attacks on air pollution at the Federal, State, and local levels, embodying objective tests, are a necessity now because the common-law nuisance action is no longer adequate to cope with the problem in its now overwhelming form.

Accelerated scientific study is also needed, and it is evident the necessary research cannot be done by a court in a nuisance action.

As technology advances and means are developed for controlling harmful unburned hydrocarbons Federal, State, and local standards will undoubtedly be revised and tightened to a degree which would have been considered unreasonable at the time of their enactment in the light of scientific knowledge then available.

Municipalities are aware of their own legal limitations in controlling smoke and fumes. While there is not a great deal of doubt by this time as to the ability of a municipal corporation to take certain

steps to control air pollution under their police powers it is still necessary to insure that any action taken does not exceed constitutional, charter, or statutory limitations. And even where governing authority has been found, action at the municipal level depends, for its validity, on its reasonableness. The test for reasonableness presents no hard and fast rule; rather it involves a weighing of all the advantages and disadvantages to private property rights and to the general public.

Federal legislation, too, must satisfy constitutional tests based on reasonableness. H. R. 9368, in granting the Surgeon General of the Public Health Service the limited authority to promulgate objective standards so as to eliminate only such emission by motor vehicles of unburned hydrocarbons as will prove harmful to human health, appears to be a reasonable measure manifestly in the public interest. For these reasons, and in light of the foregoing discussion, the National Institute of Municipal Law Officers supports and recommends its passage.

Gentlemen, I thank you for this opportunity to appear and offer our statement.

Mr. LOSER. Thank you very much.

Mr. Schenck, have you any questions?

Mr. SCHENCK. I have no questions, Mr. Chairman. I do appreciate the statement.

Mr. LOSER. Thank you very much for your appearance here and the very fine statement you have made.

Without objection, we will make a part of the record a telegram from Sacramento, Calif., with reference to this bill by the gentleman from Ohio, Mr. Schenck.

It comes from a committee of the Legislature of California. It will be made a part of the record.

(The document referred to follows:)

[Telegram]

SACRAMENTO, CALIF.

Hon. KENNETH ROBERTS,
Chairman, Traffic Subcommittee, Interstate and Foreign Commerce Committee, House of Representatives, Washington, D. C.:

H. R. 9368, by Congressman Schenck, will be before your Traffic Subcommittee, Interstate and Foreign Commerce. We in the California State Legislature have a very considerable and deeply personal interest to insure the highest degree of purity possible in the air we breathe so that we may live. This fact alone is one of almost overpowering interest to every man, woman, and child in California. It has been pointed out by many traffic authorities and many research projects that unburned hydrocarbons may cause cancer. We most urgently recommend that your committee seriously consider and act favorably on H. R. 9368.

Seth J. Johnson, Chairman, Subcommittee on Public Health; George G. Crawford, W. S. Grant, Clayton A. Dills, Byron Rumford, Don Mulford, Rex Cunningham, Richard T. Hanna; Howard J. Thelin, California Assembly Subcommittee on Radiation and Air Pollution.

Mr. LOSER. Are there other witnesses here?

If not, the committee will stand adjourned subject to the call of the Chair.

(Whereupon, at 4:03 p. m., the committee adjourned, subject to the call of the Chair.)

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